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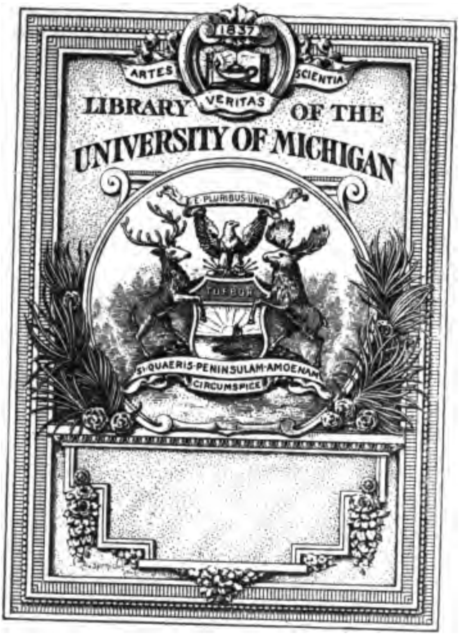
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MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

H. H. TURNER, M.A., B.Sc., Sec. R.A.S.,
SAVILIAN PROFESSOR,
T. LEWIS, F.R.A.S.,
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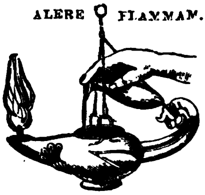
VOL. XVII.

LONDON:
TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.
1894.



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No. 209.] 1894. [*Price* 1*s*. 6*d*.

COMPANION
TO
THE OBSERVATORY,
A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

H. H. TURNER, M.A., B.Sc., Sec. R.A.S.,
T. LEWIS, F.R.A.S.,
H. P. HOLLIS, B.A., F.R.A.S.

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All Communications should be addressed to the EDITORS of the 'Observatory,' Royal Observatory, Greenwich, S.E.

Annual Subscription (for the "Companion" and twelve Monthly Numbers):—13 *shillings*.

LONDON:
PRINTED AND PUBLISHED BY TAYLOR AND FRANCIS,
RED LION COURT, FLEET STREET, E.C.

THE OBSERVATORY,

A Monthly Review of Astronomy.

EDITED BY H. H. TURNER, M.A., B.Sc., Sec. R.A.S.,
T. LEWIS, F.R.A.S., AND H. P. HOLLIS, B.A., F.R.A.S.

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ANNUAL COMPANION

TO

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 209. 1894. Vol. XVII.

INTRODUCTION.

The present 'Companion' closely resembles that of last year.

As in former years, we have to thank Mr. Denning for revising the "Meteor Notes," and Mr. Maw for kindly supplying a number of observations of Double Stars.

M. Loewy has again favoured us with advance-proofs from which we have obtained the Variable Star Ephemerides. The occultations and phenomena of Jupiter's Satellites are from the 'Nautical Almanac'; the diagrams and Ephemerides of the Satellites of the other planets from the 'American Ephemeris.' No Ephemeris of Jupiter's 5th satellite based on recent observations being yet available, this will be given, when possible, in the monthly numbers.

The "Fraction of the Year" is the fraction which has elapsed at mean noon of the particular day. The Moon's declination is given for mean midnight. The "Longitude of the Moon's Terminator" is given for mean midnight; the letters M. and E. signifying morning and evening—that is, that the Sun is rising or setting on that particular longitude of the Moon's surface; the sign – indicates longitudes reckoned from the central meridian in a westward direction. The angles of disappearance and reappearance for occultations are reckoned from the *true* north in the direction N. E. S. W., as for double stars.

Greenwich Mean Time is used in all cases, and the astronomical day is reckoned from noon to noon as in previous years.

Date.	Day of Year.	Fr. of Year.	Sun Sets.	Sun Rises.	☉'s Dec. Noon.	M.T. at Apparent Noon.	Sid. T. at Mean Noon.	Moon's Phases.
			h m	h m	° ′	h m s	h m s	d h m
Jan. 1	1	·000	4 0	20 8	22 59 S	0 3 53	18 44 29	● 6 15 7
8	8	·019	4 [illegible]	20 6	22 13	7 1	19 12 5	☽ 14 12 9
15	15	·038	4 1	20 2	21 5	9 44	19 39 38	○ 21 3 11
22	22	·058	4 2[illegible]	19 54	19 7	11 52	20 7 17	☾ 28 4 51
29	29	·077	4 4[illegible]	19 44	17 51	13 23	20 34 53	
Feb. 5	36	·096	4 5[illegible]	19 33	15 50	14 14	21 2 29	● 5 9 45
12	43	·115	5 7	19 20	13 36	14 26	21 30 5	☽ 12 22 43
19	50	·134	5 20	19 6	11 10	13 59	21 57 40	○ 19 14 16
26	57	·153	5 32	18 51	8 36	13 2	22 25 16	☾ 27 0 28
Mar. 5	64	·173	5 45	18 36	5 57	11 37	22 52 52	● 7 2 19
12	71	·192	5 57	18 21	3 12	9 51	23 20 28	☽ 14 6 28
19	78	·211	6 9	18 5	0 27 S	7 50	23 48 4	○ 21 2 11
26	85	·230	6 21	17 49	2 19 N	5 42	0 15 40	☾ 28 20 28
April 2	92	·249	6 32	17 33	5 2	3 34	0 43 16	● 5 16 0
9	99	·268	6 45	17 17	7 40	0 1 33	1 10 52	☽ 12 12 33
16	106	·288	6 55	17 2	10 13	23 59 44	1 38 28	○ 19 15 2
23	113	·307	7 7	16 47	12 37	58 13	2 6 4	☾ 27 15 21
30	120	·326	7 19	16 34	14 51	57 5	2 33 39	
May 7	127	·345	7 30	16 21	16 53	56 28	3 1 15	● 5 2 42
14	134	·364	7 40	16 10	18 42	56 9	3 28 51	☽ 11 18 21
21	141	·383	7 51	16 1	20 15	56 22	3 56 27	○ 19 4 43
28	148	·403	8 0	15 53	21 31	57 2	4 24 3	☾ 27 8 4
June 4	155	·422	8 8	15 48	22 28	58 4	4 51 39	● 3 10 56
11	162	·441	8 14	15 45	23 6	23 59 23	5 19 15	☽ 10 1 14
18	169	·460	8 17	15 44	23 26	0 0 52	5 46 51	○ 17 19 6
25	176	·479	8 19	15 46	23 24	2 22	6 14 26	☾ 25 22 3
July 2	183	·498	8 17	15 50	23 2	3 47	6 42 2	● 2 17 46
9	190	·518	8 14	15 57	22 21	4 59	7 9 39	☽ 9 10 15
16	197	·537	8 8	16 4	21 20	5 50	7 37 15	○ 17 10 3
23	204	·556	8 0	16 14	20 2	6 15	8 4 50	☾ 25 9 7
30	211	·575	7 50	16 24	18 28	6 13	8 32 26	
Aug. 6	218	·594	7 38	16 34	16 39	5 42	9 0 2	● 1 0 24
13	225	·613	7 25	16 45	14 37	4 41	9 27 38	☽ 7 22 5
20	232	·633	7 12	16 57	12 23	3 13	9 55 14	○ 16 1 17
27	239	·652	6 57	17 8	9 59	0 1 22	10 22 49	☾ 23 17 40 ● 30 8 5
Sept. 3	246	·671	6 41	17 19	7 28	23 59 14	10 50 26	☽ 6 13 3
10	253	·690	6 25	17 30	4 51	56 43	11 18 2	○ 14 16 22
17	260	·709	6 9	17 41	2 10 N	54 25	11 45 37	☾ 22 0 32
24	267	·728	5 53	17 53	0 34 S	51 57	12 13 13	● 28 17 44
Oct. 1	274	·747	5 37	18 4	3 17	49 38	12 40 49	☽ 6 7 1
8	281	·767	5 21	18 16	5 59	47 33	13 8 25	○ 14 6 41
15	288	·786	5 6	18 27	8 37	45 48	13 36 1	☾ 21 6 56
22	295	·805	4 51	18 40	11 9	44 31	14 3 37	● 28 5 57
29	302	·824	4 37	18 52	13 33	43 48	14 31 13	
Nov. 5	309	·843	4 24	19 5	15 47	43 43	14 58 39	☽ 5 3 16
12	316	·862	4 13	19 17	17 47	44 17	15 26 25	○ 12 19 49
19	323	·882	4 4	19 29	19 33	45 33	15 54 0	☾ 19 14 8
26	330	·901	3 56	19 40	21 1	47 30	16 21 36	● 26 20 54
Dec. 3	337	·920	3 51	19 50	22 9	50 2	16 49 12	☽ 5 0 15
10	344	·939	3 49	19 58	22 57	53 2	17 16 48	○ 12 7 46
17	351	·958	3 49	20 4	23 23	56 22	17 44 24	☾ 18 23 16
24	358	·977	3 52	20 8	23 26	23 59 1	18 12 0	● 26 14 20
31	365	·997	3 57	20 9	23 5	0 3 18	18 39 36	

For Moon's phases: ● signifies New; ☽ First Quarter; ○ Full; ☾ Last Quarter.

JANUARY.

Day.		Moon.			
Month.	Week.	Rises.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	M	16 2	20 19	19 2 S	+29·1 E.
2	Tu	17 16	21 6	22 59	+41·3 E.
3	W	18 26	21 55	25 56	+53·5 E.
4	Th	19 31	22 45	27 45	+65·7 E.
5	F	20 24	23 37	28 17	+77·8 E.
6	S	sets	……	27 31	……
7	**S**	3 58	0 28	25 29	−78·0 M.
8	M	5 10	1 17	22 18	−65·8 M.
9	Tu	6 26	2 4	18 8	−53·6 M.
10	W	7 41	2 49	13 12	−41·5 M.
11	Th	8 56	3 32	7 40	−29·4 M.
12	F	10 11	4 14	1 44 S	−17·2 M.
13	S	11 27	4 56	4 24 N	− 5·1 M.
14	**S**	12 45	5 41	10 30 N	+ 7·1 M.
15	M	14 10	6 28	16 18	+19·3 M.
16	Tu	15 39	7 20	21 26	+31·5 M.
17	W	17 7	8 18	25 26	+43·7 M.
18	Th	18 31	9 22	27 51	+55·8 M.
19	F	19 36	10 29	28 16	+67·9 M.
20	S	rises	11 36	26 33	+80·0 M.
21	**S**	4 5	12 39	22 55	−87·8 E.
22	M	5 38	13 37	17 50	−75·7 E.
23	Tu	7 10	14 29	11 51	−63·5 E.
24	W	8 36	15 18	5 25 N	−51·4 E.
25	Th	9 57	16 3	1 2 S	−39·2 E.
26	F	11 15	16 47	7 14	−27·0 E.
27	S	12 32	17 30	12 57	−14·9 E.
28	**S**	13 48	18 15	18 0	− 2·7 E.
29	M	15 5	19 1	22 13	+ 9·5 E.
30	Tu	16 17	19 50	25 27	+21·7 E.
31	W	17 25	20 40	27 33 S	+33·8 E.

FEBRUARY.

Day.		Moon.			
Month.	Week.	Rises.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	Th	18 21	21 32	28 24 S	+46·0 E.
2	F	19 3	22 23	27 57	+58·1 E.
3	S	19 36	23 13	26 12	+70·3 E.
4	**S**	sets	……	23 14	+82·5 E.
5	M	4 13	0 1	19 14	……
6	Tu	5 29	0 47	14 23	−73·2 M.
7	W	6 46	1 31	8 52	−61·0 M.
8	Th	8 2	2 13	2 56 S	−48·9 M.
9	F	9 18	2 56	3 12 N	−36·[illegible] M.
10	S	10 34	3 39	9 20	−24·5 M.
11	**S**	11 56	4 25	15 9	−12·3 M.
12	M	13 22	5 14	20 22	− 0·2 M.
13	Tu	14 49	6 8	24 36	+12·0 M.
14	W	16 11	7 8	27 27	+24·1 M.
15	Th	17 22	8 11	28 31	+36·3 M.
16	F	18 16	9 16	27 36	+48·4 M.
17	S	18 51	10 20	24 45	+60·6 M.
18	**S**	rises	11 19	20 16	+72·8 M.
19	M	4 33	12 14	14 36	+85·0 M.
20	Tu	6 4	13 4	8 14	−82·9 E.
21	W	7 28	13 52	1 37 N	−70·7 E.
22	Th	8 49	14 37	4 54 S	−58·5 E.
23	F	10 9	15 22	11 0	−46·4 E.
24	S	11 29	16 7	16 28	−34·2 E.
25	**S**	12 47	16 54	21 6	−22·0 E.
26	M	14 3	17 43	24 44	− 9·9 E.
27	Tu	15 12	18 33	27 13	+ 2·3 E.
28	W	16 14	19 24	28 28 S	+14·5 E.

MARCH.

Day.		Moon.			
Month.	Week.	Rises.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	Th	17 2	20 16	28 23 S	+26·7 E.
2	F	17 38	21 6	26 59	+38·9 E.
3	S	18 5	21 55	24 22	+51·0 E.
4	**S**	18 21	22 42	20 38	+63·2 E.
5	M	sets	23 27	15 57	+75·4 E.
6	Tu	4 29	……	10 32	+87·6 E.
7	W	5 47	0 10	4 35 S	−80·2 M.
8	Th	7 4	0 53	1 39 N	−68·1 M.
9	F	8 22	1 37	7 56	−55·9 M.
10	S	9 43	2 23	13 57	−43·7 M.
11	**S**	11 9	3 11	19 24	−31·6 M.
12	M	12 36	4 4	23 54	−19·4 M.
13	Tu	14 1	5 1	27 4	− 7·2 M.
14	W	15 14	6 3	28 33	+ 5·0 M.
15	Th	16 12	7 6	28 11	+17·2 M.
16	F	16 52	8 8	25 56	+29·3 M.
17	S	17 19	9 7	22 2	+41·5 M.
18	**S**	17 38	10 2	16 51	+53·6 M.
19	M	17 52	10 53	10 48	+65·7 M.
20	Tu	rises	11 41	4 18 N	+77·8 M.
21	W	6 23	12 27	2 17 S	……
22	Th	7 44	13 12	8 38	−77·5 E.
23	F	9 3	13 58	14 27	−65·3 E.
24	S	10 23	14 45	19 31	−53·2 E.
25	**S**	11 43	15 33	23 37	−41·0 E.
26	M	12 56	16 24	26 34	−28·9 E.
27	Tu	14 3	17 15	28 16	−16·8 E.
28	W	14 58	18 7	28 38	− 4·6 E.
29	Th	15 37	18 58	27 40	+ 7·7 E.
30	F	16 9	19 47	25 27	+20·0 E.
31	S	16 28	20 35	22 5 S	+32·2 E.

Day.		Moon.			
Month.	Week.	Rises.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	**S**	16 44	21 20	17 43 S	+44·4 E.
2	M	16 56	22 4	12 33	+56·5 E.
3	Tu	17 8	22 47	6 44	+68·7 E.
4	W	17 19	23 31	0 31 S	+80·9 E.
5	Th	sets	……	5 53 N	−86·9 M.
6	F	7 24	0 17	12 9	−74·7 M.
7	S	8 50	1 5	17 56	−62·5 M.
8	**S**	10 19	1 58	22 51	−50·4 M.
9	M	11 47	2 55	26 27	−38·2 M.
10	Tu	13 8	3 56	28 23	−26·0 M.
11	W	14 11	5 0	28 26	−13·9 M.
12	Th	14 55	6 2	26 36	− 1·7 M.
13	F	15 25	7 2	23 7	+10·6 M.
14	S	15 47	7 57	18 19	+22·8 M.
15	**S**	16 1	8 4	12 36	+35·0 M.
16	M	16 14	9 35	6 21 N	+47·2 M.
17	Tu	16 25	10 21	0 6 S	+59·3 M.
18	W	16 37	11 5	6 27	+71·5 M.
19	Th	rises	11 50	12 26	+83·7 M
20	F	8 3	12 36	17 46	−83·9 E
21	S	9 21	13 24	22 14	−71·7 E
22	**S**	10 37	14 14	25 38	−59·5 E.
23	M	11 48	15 6	27 47	−47·4 E.
24	Tu	12 28	15 58	28 36	−35·2 E.
25	W	13 34	16 49	28 5	−23·0 E.
26	Th	14 8	17 39	26 16	−10·8 E.
27	F	14 32	18 27	23 17	+ 1·5 E.
28	S	14 48	19 31	19 18	+13·7 E.
29	**S**	15 3	19 56	14 28	+25·9 E.
30	M	15 15	20 39	8 57 S	+38·0 E.

MAY.

Day.		Moon.			
Month.	Week.	Rises.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	Tu	15 26	21 22	2 56 S	+50·3 E.
2	W	15 36	22 7	3 23 N	+62·5 E.
3	Th	15 49	22 54	9 45	+74·7 E.
4	F	sets	23 46	15 49	+86·9 E.
5	S	7 52	……	21 11	−80·1 M.
6	**S**	9 24	0 43	25 22	−68·0 M.
7	M	10 51	1 44	27 55	−56·0 M.
8	Tu	12 2	2 49	28 31	−43·8 M.
9	W	12 54	3 54	27 7	−31·7 M.
10	Th	13 28	4 56	23 57	−19·6 M.
11	F	13 52	5 54	19 23	− 7·6 M.
12	S	14 8	6 46	13 51	+ 4·6 M.
13	**S**	14 21	7 34	7 45	+16·8 M.
14	M	14 32	8 19	1 25 N	+29·0 M.
15	Tu	14 42	9 3	4 52 S	+41·1 M.
16	W	14 54	9 46	10 50	+53·3 M.
17	Th	15 7	10 31	16 17	+65·5 M.
18	F	rises	11 18	20 58	+77·6 M.
19	S	8 19	12 7	24 39	……
20	**S**	9 33	12 58	27 10	−77·7 E.
21	M	10 38	13 50	28 23	−65·5 E.
22	Tu	11 29	14 42	28 15	−53·3 E.
23	W	12 7	15 33	26 48	−41·2 E.
24	Th	12 34	16 21	24 10	−29·0 E.
25	F	12 53	17 7	20 30	−16·8 E.
26	S	13 9	17 51	15 59	− 4·5 E.
27	**S**	13 19	18 33	10 46	+ 7·7 E.
28	M	13 31	19 15	5 2 S	+19·9 E.
29	Tu	13 41	19 58	1 4 N	+32·1 E.
30	W	13 53	20 43	7 18	+44·3 E.
31	Th	14 6	21 32	13 26 N	+56·5 E.

JUNE.

Day.		Moon.			
Month.	Week.	Rises	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	F	14 28	22 26	19 5 N	+68·9 E.
2	S	14 51	23 26	23 48	+81·2 E.
3	**S**	sets	……	27 4	−86·6 M.
4	M	9 41	0 31	28 26	−74·3 M.
5	Tu	10 44	1 38	27 41	−62·1 M.
6	W	11 27	2 44	24 57	−49·8 M.
7	Th	11 55	3 45	20 36	−37·6 M.
8	F	12 14	4 41	15 9	−25·3 M.
9	S	12 27	5 31	9 3	−13·0 M.
10	**S**	12 40	6 18	2 41 N	− 0·8 M.
11	M	12 51	7 2	3 37 S	+11·1 M.
12	Tu	13 3	7 45	9 39	+23·4 M.
13	W	13 14	8 30	15 10	+35·6 M.
14	Th	13 30	9 15	19 58	+47·8 M.
15	F	13 50	10 3	23 51	+60·1 M.
16	S	14 20	10 53	26 38	+72·4 M.
17	**S**	rises	11 44	28 9	+84·6 M.
18	M	9 25	12 37	28 20	−83·3 E.
19	Tu	10 6	13 28	27 12	−71·0 E.
20	W	10 37	14 17	24 50	−58·8 E.
21	Th	10 59	15 3	21 25	−46·5 E.
22	F	11 15	15 47	17 7	−34·2 E.
23	S	11 28	16 30	12 7	−22·0 E.
24	**S**	11 38	17 11	6 36	− 9·8 E.
25	M	11 48	17 52	0 43 S	+ 2·2 E.
26	Tu	11 59	18 35	5 20 N	+14·5 E.
27	W	12 12	19 20	11 21	+26·7 E.
28	Th	12 26	20 10	17 4	+39·0 E.
29	F	12 46	21 6	22 5	+51·3 E.
30	S	13 17	22 8	25 56 N	+63·5 E.

JULY.

Day.		Moon.			
Month.	Week.	Rises.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	**S**	14 6	23 15	28 6 N	+75·6 E.
2	M	sets	……	28 14	+87·8 E.
3	Tu	9 20	0 23	26 13	−80·0 M.
4	W	9 54	1 28	22 19	−67·8 M.
5	Th	10 17	2 28	17 1	−55·5 M.
6	F	10 34	3 23	10 52	−43·2 M.
7	S	10 46	4 12	4 20 N	−31·0 M.
8	**S**	10 58	4 59	2 11 S	−18·7 M.
9	M	11 9	5 43	8 25	− 6·5 M.
10	Tu	11 21	6 28	14 7	+ 5·6 M.
11	W	11 37	7 13	19 6	+17·8 M.
12	Th	11 55	8 0	23 11	+30·1 M.
13	F	12 21	8 49	26 12	+42·3 M.
14	S	12 56	9 40	27 59	+54·5 M.
15	**S**	13 44	10 32	28 27	+66·7 M.
16	M	14 45	11 24	27 35	+79·0 M.
17	Tu	rises	12 14	25 29	−88·9 E.
18	W	9 4	13 1	22 16	−76·7 E.
19	Th	9 21	13 46	18 7	−64·5 E.
20	F	9 35	14 28	13 14	−52·2 E.
21	S	9 47	15 10	7 50	−40·0 E.
22	**S**	9 57	15 50	2 3 S	−27·8 E.
23	M	10 6	16 31	3 54 N	−15·6 E.
24	Tu	10 18	17 15	9 50	− 3·3 E.
25	W	10 30	18 2	15 30	+ 8·9 E.
26	Th	10 48	18 53	20 38	+21·1 E.
27	F	11 12	19 51	24 49	+33·3 E.
28	S	11 50	20 54	27 35	+45·5 E.
29	**S**	12 48	22 0	28 32	+57·8 E.
30	M	14 7	23 7	27 24	+70·0 E.

AUGUST.

Day.		Moon.			
Month.	Week.	Sets.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	W	8 17	0 10	19 23 N	−85·6 M.
2	Th	8 37	1 8	13 23	−73·4 M
3	F	8 51	2 1	6 45 N	−61·2 M.
4	S	9 4	2 50	0 2 S	−49·0 M.
5	**S**	9 16	3 37	6 36	−36·7 M.
6	M	9 28	4 23	12 40	−24·5 M.
7	Tu	9 42	5 9	18 0	−12·2 M.
8	W	9 58	5 56	22 24	0·0 M.
9	Th	10 23	6 45	25 43	+12·2 M.
10	F	10 54	7 36	27 49	+24·4 M.
11	S	11 38	8 28	28 35	+36·6 M.
12	**S**	12 36	9 20	28 2	+48·9 M.
13	M	13 42	10 10	26 11	+61·1 M.
14	Tu	14 56	10 58	23 12	+73·3 M.
15	W	16 10	11 44	19 13	+85·6 M.
16	Th	rises	12 27	14 27	−82·1 E.
17	F	7 55	13 9	9 5	−69·9 E.
18	S	8 5	13 50	3 19 S	−57·6 E.
19	**S**	8 13	14 31	2 38 N	−45·4 E.
20	M	8 26	15 13	8 36	−33·2 E.
21	Tu	8 38	15 58	14 19	−21·0 E.
22	W	8 53	16 47	19 32	− 8·7 E.
23	Th	9 13	17 41	23 55	+ 3·5 E.
24	F	9 44	18 40	27 3	+15·7 E.
25	S	10 32	19 43	28 35	+27·8 E.
26	**S**	11 39	20 48	28 12	+39·9 E.
27	M	13 6	21 51	25 50	+52·1 E.
28	Tu	14 40	22 51	21 41	+64·3 E.
29	W	16 14	23 46	16 8	+76·5 E.
30	Th	sets	……	9 40	+88·6 E.

SEPTEMBER.

Day.		Moon.			
Month.	Week.	Sets.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	S	7 21	1 25	4 3 S	−66·9 M.
2	**S**	7 33	2 13	10 31	−54·7 M.
3	M	7 46	3 0	16 19	−42·5 M.
4	Tu	8 1	3 48	21 11	−30·3 M.
5	W	8 23	4 38	24 57	−18·0 M.
6	Th	8 52	5 29	27 28	− 5·8 M.
7	F	9 31	6 21	28 38	+ 6·4 M.
8	S	10 25	7 13	28 26	+18·6 M.
9	**S**	11 30	8 5	26 56	+30·8 M.
10	M	12 41	8 54	24 14	+43·0 M.
11	Tu	13 56	9 40	20 29	+55·2 M.
12	W	15 11	10 25	15 53	+67·4 M.
13	Th	16 25	11 7	10 37	+79·6 M.
14	F	rises	11 48	4 53 S	− 88 1 E.
15	S	6 24	12 30	1 8 N	−75·9 E.
16	**S**	6 35	13 12	7 12	−63·7 E.
17	M	6 45	13 57	13 5	−51·5 E.
18	Tu	6 58	14 45	18 29	−39·3 E.
19	W	7 17	15 37	23 5	−27·1 E.
20	Th	7 45	16 34	26 31	−14 9 E.
21	F	8 27	17 34	28 26	− 2·8 E.
22	S	9 25	18 37	28 34	+ 9·4 E.
23	**S**	10 42	19 39	26 49	+21·5 E.
24	M	12 11	20 38	23 19	+33·7 E.
25	Tu	13 44	21 33	18 21	+45·9 E.
26	W	15 14	22 25	12 19	+58·1 E.
27	Th	16 42	23 14	5 40 N	+70·3 E.
28	F	18 8	......	1 12 S	+82·5 E.
29	S	sets	0 1	7 53	−85·3 M.
30	**S**	5 51	0 49	14 3 S	−73·1 M.

OCTOBER.

Day.		Moon.			
Month.	Week.	Sets.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	M	6 6	1 37	19 25 S	−60·9 M.
2	Tu	6 25	2 27	23 42	−48·7 M.
3	W	6 50	3 19	26 44	−36·5 M.
4	Th	7 26	4 11	28 24	−24·3 M.
5	F	8 14	5 5	28 40	−12·1 M.
6	S	9 15	5 57	27 33	0·0 M.
7	**S**	10 24	6 47	25 13	+12·2 M.
8	M	11 38	7 34	21 48	+24·4 M.
9	Tu	12 53	8 19	17 28	+36·6 M.
10	W	14 7	9 2	12 25	+48·8 M.
11	Th	15 21	9 44	6 48	+60·0 M.
12	F	16 35	10 26	0 49 S	+72·2 M.
13	S	17 32	11 8	5 19 N	+84·6 M.
14	**S**	19 12	11 52	11 22	−82·5 E.
15	M	rises.	12 40	17 2	−70·3 E.
16	Tu	5 24	13 32	21 58	−58·2 E.
17	W	5 48	14 28	25 46	−46·0 E.
18	Th	6 26	15 28	28 6	−33·8 E.
19	F	7 19	16 31	28 38	−21·6 E.
20	S	8 30	17 33	27 19	− 9·4 E.
21	**S**	9 55	18 32	24 16	+ 2·8 E.
22	M	11 24	19 27	19 44	+15·0 E.
23	Tu	12 54	20 18	14 8	+27·2 E.
24	W	14 20	21 6	7 49	+39·4 E.
25	Th	15 43	21 53	1 10 N	+51·6 E.
26	F	17 6	22 39	5 28 S	+63·8 E.
27	S	18 29	23 27	11 46	+76·0 E.
28	**S**	sets	......	17 25	+88·1 E.
29	M	4 28	0 16	22 8	−79·8 M.
30	Tu	4 50	1 7	25 40	−67·6 M.
31	W	5 21	2 0	27 52 S	−55·4 M.

NOVEMBER.

Day.		Moon.			
Month.	Week.	Sets.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	Th	6 5	2 54	28 37 S	−43·2 M.
2	F	7 1	3 47	27 58	−31·0 M.
3	S	8 9	4 38	26 1	−18·8 M.
4	**S**	9 20	5 27	22 57	− 6·6 M.
5	M	10 35	6 16	18 56	+ 5·5 M.
6	Tu	11 49	6 56	14 9	+17·6 M.
7	W	13 1	7 38	8 47	+29·8 M.
8	Th	14 14	8 19	3 0 S	+42·0 M.
9	F	15 30	9 1	3 3 N	+54·2 M.
10	S	16 47	9 44	9 9	+66·3 M.
11	**S**	18 9	10 30	15 0	+78·5 M.
12	M	19 35	11 21	20 18	......
13	Tu	rises	12 17	24 36	−77·2 E.
14	W	4 21	13 18	27 28	−65·0 E.
15	Th	5 7	14 22	28 33	−52·8 E.
16	F	6 19	15 26	27 40	−40·7 E
17	S	7 42	16 27	24 57	−28·5 E.
18	**S**	9 12	17 23	20 41	−16·3 E.
19	M	10 39	18 15	15 17	− 4·1 E.
20	Tu	12 7	19 4	9 10	+ 8·0 E.
21	W	13 29	19 50	2 42 N	+20·2 E.
22	Th	14 50	20 35	3 48 S	+32·4 E.
23	F	16 11	21 21	10 3	+44·5 E.
24	S	17 33	22 8	15 47	+56·7 E.
25	**S**	18 55	22 58	20 42	+68·9 E.
26	M	20 14	23 50	24 35	+81·0 E.
27	Tu	sets	......	27 11	−86·9 M.
28	W	3 59	0 43	28 24	−74·7 M.
29	Th	4 49	1 37	28 11	−62·5 M.
30	F	5 54	2 30	26 37 S	−50·3 M.

Day.		Moon.			
Month.	Week.	Sets.	Souths.	Dec.	Long. of Terminator.
		h m	h m	° ′	°
1	S	7 4	3 20	23 51 S	−38·2 M.
2	**S**	8 18	4 7	20 7	−26·0 M.
3	M	9 31	4 51	15 37	−13·8 M.
4	Tu	10 44	5 32	10 29	− 1·6 M.
5	W	11 54	6 13	4 56 S	+10·5 M.
6	Th	13 8	6 53	0 55 N	+22·7 M.
7	F	14 22	7 35	6 53	+34·9 M.
8	S	15 41	8 19	12 45	+47·0 M.
9	**S**	17 5	9 7	18 14	+59·2 M.
10	M	18 31	10 0	22 58	+71·3 M.
11	Tu	20 0	10 59	26 28	+83·4 M.
12	W	rises	12 3	28 17	−84·5 E.
13	Th	4 0	13 10	28 5	−72·3 E.
14	F	5 19	14 15	25 52	−60·1 E.
15	S	6 50	15 15	21 53	−48·0 E.
16	**S**	8 25	16 10	16 35	−35·8 E.
17	M	9 54	17 1	10 28	−23·7 E.
18	Tu	11 18	17 48	3 57 N	−11·5 E.
19	W	12 39	18 34	2 35 S	+ 0·7 E.
20	Th	14 1	19 19	8 53	+12·8 E.
21	F	15 20	20 5	14 39	+25·0 E.
22	S	16 42	20 54	19 41	+37·2 E.
23	**S**	18 0	21 44	23 45	+49·2 E.
24	M	19 14	22 36	26 38	+61·4 E.
25	Tu	20 19	23 30	28 11	+73·6 E.
26	W	sets	......	28 19	+85·7 E.
27	Th	3 42	0 23	27 6	−82·1 M.
28	F	4 50	1 14	24 38	−70·0 M.
29	S	6 3	2 2	21 8	−57·8 M.
30	**S**	7 18	2 47	16 48	−45·6 M.
31	M	8 29	3 29	11 51 S	−33·5 M.

List of the principal Meteor-showers of the Year, derived from recent Observations. By W. F. Denning.

Date.	Radiant.		Meteors.	Date.	Radiant.		Meteors.
	α °	δ °			α °	δ °	
Jan. 2 ...	**230**	**+53**	Swift; long paths.	July 28 ...	**339**	**−12**	Slow; long.
3 ...	156	+41	Swift.	30 ...	6	+35	Swift; streaks.
11 ...	220	+13	Swift; streaks.	Aug. 4 ...	30	+36	Swift; streaks.
17 ...	295	+53	Slow; bright.	10 ...	**45**	**+57**	Swift; streaks.
22 ...	208	− 8	Very swift; streaks.	14 ...	311	+62	Rather swift.
25 ...	131	+32	Swift.	15 ...	292	+53	Swift; bright.
29 ...	213	+52	Very swift.	16 ...	61	+48	Swift; streaks.
Feb. 1 ...	211	+69	Slow; short.	21 ...	73	+41	Swift; streaks.
15 ...	236	+11	Swift; streaks.	22 ...	291	+60	Slow; bright.
15 ...	261	+ 4	Swift; streaks.	23 ...	70	+50	Swift; streaks.
20 ...	181	+34	Swift; bright.	25 ...	5	+11	Slow; short.
20 ...	263	+36	Swift; streaks.	Sept. 3 ...	354	+38	Very swift.
Mar. 1 ...	47	+45	Very slow.	7 ...	62	+37	Swift; streaks.
14 ...	175	+10	Slow; bright.	15 ...	48	+44	Very swift.
18 ...	316	+76	Slow; bright.	21 ...	31	+19	Slow.
24 ...	161	+58	Swift.	22 ...	335	+58	Slowish.
27 ...	229	+32	Swift; small.	22 ...	63	+22	Swift; streaks.
28 ...	263	+62	Rather swift.	27 ...	75	+15	Swift; streaks.
Apr. 17 ...	165	− 6	Very slow.	Oct. 2 ...	225	+52	Slow; bright.
18 ...	213	+53	Swift; short.	4 ...	133	+79	Swift; streaks.
18 ...	231	+17	Swift; short.	4 ...	310	+77	Slowish.
19 ...	218	+33	Slow; bright.	8 ...	77	+31	Swift; streaks.
19 ...	229	− 2	Slow; long.	11 ...	13	+ 6	Slow; bright.
20 ...	**270**	**+33**	Swift.	14 ...	40	+20	Rather swift.
25 ...	272	+21	Swift; short.	14 ...	135	+68	Swift; streaks.
May 1 ...	239	+46	Small; short.	18 ...	**92**	**+15**	Swift; streaks.
5 ...	254	−21	Slowish.	20 ...	106	+12	Swift; streaks.
6 ...	**338**	**− 2**	Swift; streaks.	29 ...	109	+23	Very swift.
7 ...	244	+ 7	Slow; bright.	Nov. 1 ...	43	+22	Slow; bright.
14 ...	314	+15	Swift; streaks.	2 ...	55	+ 9	Slow; bright.
29 ...	264	+64	Slowish.	13 ...	**150**	**+22**	Swift; streaks.
30 ...	333	+27	Swift; streaks.	16 ...	154	+41	Swift; streaks.
June 7 ...	247	−25	Slow; very bright.	17 ..	53	+71	Slowish.
10 ...	261	+ 5	Very slow.	20 ...	62	+23	Slow; bright.
13 ...	310	+61	Swift; streaks.	23-27	**25**	**+44**	Very slow; trains.
15 ...	291	+52	Swift; small.	30 ...	190	+58	Swift; streaks.
15 ...	285	+23	Slowish.	Dec. 4 ...	162	+58	Swift; streaks.
20 ...	335	+57	Swift.	4 ...	110	+25	Slowish.
28 ...	294	+39	Slow.	6 ...	80	+23	Slow; bright.
July 4 ...	303	+24	Swift.	8 ...	145	+ 7	Swift; streaks.
11 ...	349	+53	Swift.	8 ...	208	+71	Rather swift.
19 ...	314	+48	Swift; short.	10 ...	**108**	**+33**	Swift; short.
20 ...	269	+49	Swift.	12 ...	119	+29	Rather swift.
22 ...	16	+31	Swift; streaks.	24 ...	218	+36	Swift; streaks.
25 ...	48	+43	Swift; streaks.	25 ...	98	+31	Very slow.

The radiant-points of the more brilliant showers are indicated by heavier type.

The Perseids, with max. on August 10, are visible for a considerable period and their radiant-point exhibits an easterly motion amongst the stars. The following is an ephemeris:—

Date.	Radiant.		Date.	Radiant.		Date.	Radiant.	
	α °	δ °		α °	δ °		α °	δ °
July 19 ...	19	+51	July 29 ...	32	+54	Aug. 8 ...	42	+57
21 ...	22	+52	31 ...	34	+55	10 ...	45	+57
23 ...	25	+52	Aug. 2 ...	36	+55	12 ...	47	+57
25 ...	27	+53	4 ...	38	+56	14 ...	50	+58
27 ...	30	+54	6 ...	40	+56	16 ...	53	+58

	Mercury (☿).						Venus (♀).						Mars (♂).					
1893.	R.A. Noon.	Dec. Noon.	Diam.	Rises.	Transits.	Sets.	R.A. Noon.	Dec. Noon.	Diam.	Rises.	Transits.	Sets.	R.A. Noon.	Dec. Noon.	Diam.	Rises.	Transits.	Sets.
	h m s	° ′	″	h m	h m	h m	h m s	° ′	″	h m	h m	h m	h m s	° ′	″	h m	h m	h m
Jan. 1..	17 38 39	23 25 S.	5·0	19 5	22 57	2 49	21 50 31	13 18 S.	34·6	22 10	3 6	8 2	15 52 44	19 57 S.	5·2	16 52	21 7	1 22
11...	18 44 52	24 12	4·8	19 36	23 24	3 12	22 12 24	9 36	40·2	21 30	2 48	8 6	16 21 15	21 20	5·4	16 51	20 56	1 1
21...	19 54 10	22 47	4·8	19 58	23 54	3 50	22 23 11	6 22	47·2	20 50	2 20	7 50	16 50 26	22 26	5·6	16 48	20 46	0 44
31..	21 4 40	18 53	4·8	20 0	0 22	4 45	22 19 46	4 13	54·6	19 54	1 37	7 20	17 20 9	23 12	5·8	16 45	20 37	0 29
Feb. 10...	22 14 20	12 30	5·2	19 50	0 52	5 57	22 2 7	3 43	60·0	18 55	0 40	6 25	17 50 19	23 38	6·0	16 37	20 27	0 17
20...	23 16 46	4 27 S.	6·2	19 32	1 15	6 58	21 38 19	4 58	59·6	17 53	23 31	5 9	18 20 44	23 43	6·2	16 30	20 18	0 6
Mar. 2 ..	23 51 11	1 48 N.	8·2	18 57	1 10	7 23	21 22 22	7 0	53·8	17 10	22 37	4 4	18 51 15	23 26	6·4	16 19	20 9	23 59
12...	23 37 34	1 30 N.	10·6	18 6	0 17	6 28	21 21 56	8 39	46·2	16 40	21 59	3 18	19 21 41	22 48	6·8	16 5	20 0	23 55
22...	23 9 48	3 20 S.	10·6	17 17	23 5	4 53	21 35 50	9 23	39·2	15 19	21 34	2 49	19 51 51	21 50	7·0	15 50	19 51	23 52
Apr. 1..	23 11 53	5 46	10·0	16 55	22 31	4 7	22 0 1	9 2	33·6	16 3	21 20	2 37	20 21 39	20 32	7·4	15 32	19 42	23 52
11...	23 41 18	4 21	7·6	16 40	22 23	3 57	22 30 45	7 42	29·2	15 49	21 12	2 35	20 50 57	18 57	7·8	15 10	19 31	23 52
21...	0 26 37	0 6 S.	6·4	16 32	22 30	4 28	23 5 26	5 30	25·6	17 28	21 6	0 44	21 19 39	17 7	8·2	14 48	19 21	23 54
May 1...	1 23 18	6 12 N.	5·6	16 13	22 48	5 23	23 42 33	2 36 S.	22·8	15 14	21 5	2 56	21 47 43	15 4	8·8	14 24	19 9	23 54
11...	2 32 29	13 44	5·2	16 4	23 19	6 34	0 21 17	0 47 N	20·6	14 56	21 4	3 12	22 15 8	12 51	9·4	14 1	18 57	23 53
21...	3 56 41	20 57	5·0	16 5	0 0	7 55	1 1 18	4 29	18·8	14 43	21 5	3 27	22 41 51	10 30	9·9	13 34	18 44	23 53
31...	5 27 43	25 5	5·4	15 27	0 52	9 17	1 42 39	8 17	17·2	14 21	21 7	3 53	23 7 53	8 5	10·5	13 9	18 51	23 53
June 10...	6 47 0	25 2	6·4	17 8	1 32	9 56	2 25 32	12 0	16·2	14 9	21 11	4 13	23 33 11	5 39	11·1	12 42	18 17	23 52
20...	7 44 53	22 17	7·6	17 46	1 50	9 54	3 10 9	15 26	15·0	13 51	21 16	4 41	23 57 42	3 14	11·8	12 14	18 1	23 48
30..	8 17 42	18 40	9·4	17 58	1 43	9 28	3 56 44	18 23	14·0	13 40	21 23	5 6	0 21 21	0 53 S.	12·7	11 48	17 46	23 44
July 10...	8 21 4	15 56	11·0	17 39	1 7	8 35	4 45 16	20 39	13·2	13 35	21 33	5 31	0 43 55	1 19 N.	13·8	11 19	17 29	23 39
20...	7 57 59	15 39	11·4	16 39	0 5	7 31	5 35 29	22 5	12·6	13 37	21 44	5 51	1 5 12	3 22	14·9	10 50	17 11	23 32
30...	7 39 7	17 35	9·6	15 26	23 3	6 40	6 26 51	22 31	12·2	13 43	21 56	6 3	1 24 51	5 11	15·9	10 21	16 51	23 21
Aug. 9..	7 58 57	19 21	7·2	15 0	22 48	6 37	7 18 36	21 55	11·6	14 3	22 8	6 13	1 42 19	6 45	17·1	9 51	16 29	22 57
19...	8 59 32	18 5	5·6	15 31	23 12	6 53	8 9 56	20 17	11·2	14 24	22 20	6 16	1 56 59	8 2	18·5	9 19	16 4	22 49
29...	10 16 20	12 38	5·0	16 39	23 49	6 59	9 0 14	17 41	11·0	14 52	22 31	6 10	2 8 4	8 59	20·1	8 45	15 35	22 25
Sept. 8...	11 27 15	5 3 N.	4·8	17 48	0 17	6 46	9 49 10	14 14	10·6	15 22	22 40	5 58	2 14 36	9 37	21·8	8 6	14 59	21 52
18...	12 29 19	2 44 S.	5·0	18 50	0 40	6 30	10 36 42	10 7	10·4	15 52	22 48	5 44	2 15 48	9 49	23·4	7 30	14 24	21 18
28...	13 25 36	9 51	5·2	19 45	0 57	6 9	11 23 9	5 31	10·2	16 24	22 55	5 26	2 11 15	9 42	24·9	6 46	13 40	20 34
Oct. 8...	14 17 58	15 53	5·6	20 34	1 10	5 46	12 8 59	0 38 N.	10·0	16 54	23 1	5 8	2 1 30	9 16	25·6	5 59	12 50	19 41
18..	15 4 43	20 20	6·6	21 5	1 17	5 39	12 54 50	4 20 S.	10·0	17 27	23 8	4 49	1 48 38	8 41	25·7	5 10	11 58	18 46
28...	15 34 42	22 16	8·0	21 7	1 7	5 7	13 41 21	9 10	9·9	17 59	23 15	4 31	1 35 38	8 9	24·6	4 21	11 6	17 51
Nov. 7...	15 19 35	19 25	9·8	19 58	0 13	4 31	14 29 11	13 40	9·9	18 31	23 23	4 15	1 25 29	7 51	22·8	3 29	10 16	16 55
17...	14 39 4	13 27	8·6	18 56	22 48	3 50	15 18 46	17 36	9·8	19 6	23 34	4 2	1 20 2	7 57	20·8	2 48	9 32	16 18
27...	14 54 0	14 8	6·6	18 37	22 29	3 17	16 10 21	20 45	9·8	19 37	23 46	3 55	1 19 43	8 27	18·6	2 6	8 53	15 40
Dec. 7...	15 43 30	18 19	5·4	18 10	22 40	3 4	17 3 48	22 55	9·8	20 7	* *	3 53	1 24 14	9 19	16·6	1 27	8 18	15 9
17...	16 44 28	22 9	5·0	19 3	23 3	3 3	17 58 30	23 56	9·8	20 28	0 14	4 0	1 32 51	10 29	14·9	0 56	7 48	14 40
27...	17 50 51	24 23 S.	4·6	19 44	23 30	3 17	18 53 33	23 44 S.	9·8	20 42	0 30	4 18	1 44 47	11 53 N.	13·4	0 20	7 20	14 20

Mercury.

	d h	d h	d h	d h
Gr. elong. E....	Feb. 25 14;	June 22 21;	Oct. 18 20	
„ W....	Apr. 10 11;	Aug. 8 21;	Nov. 27 5	
Sup. conj. ...	Jan. 29 0;	May 20 4;	Sept. 2 19	
Inf. conj.	Mar. 13 20;	July 20 10;	Nov. 10 7	
Stationary ...	Mar. 3 23;	Mar. 26 7;	July 6 2;	July 30 16
„ ...	Oct. 30 13;	Nov. 19 6		

Venus.

	d h	d h
Gr. brilliancy	Jan. 11 2;	Mar. 22 14
Inf. Conj. ...	Feb. 15 21	
Sup. conj. ...	Nov. 30 3	
Gr. elong. W.	Apr. 26 20	
Stationary ...	Jan. 23 19;	Mar. 7 5

Superior Planets.

	Conjunction.	Opposition.	Quadrature.		Stationary.	
	d h	d h	d h	d h	d h	d h
Mars......		Oct. 20 10	June 17 0		Sept. 15 4;	Nov. 22 14
Jupiter...	June 4 2	Dec. 22 14	Feb. 10 19;	Sept. 27 21	Jan. 15 9;	Oct. 24 0
Saturn..	Oct. 20 23	Apr. 11 6	Jan. 14 11;	July 10 14	Feb. 3 5;	June 21 20
Uranus...	Nov. 7 14	May 3 8	Feb. 3 14;	Aug. 3 6	Feb. 17 20;	July 19 17
Neptune.	June 3 10	Dec. 6 0	Feb. 28 20;	Sept. 8 0	Feb. 19 11;	Sept. 18 9

Jupiter (♃).

Saturn (♄).

1894.	R.A. Noon.	Dec. Noon.	Diam.	Rises.	Transits.	Sets.	R.A. Noon.	Dec. Noon.	Diam.	Rises.	Transits.	Se
	h m s	° ′	″	h m	h m	h m	h m s	° ′	″	h m	h m	h
Jan. 1	3 18 24	17 18 N.	42·6	0 56	8 32	16 8	13 33 28	7 9 S.	15·2	13 18	18 46	0
21	3 17 10	17 19	40·0	23 37	7 13	14 49	13 36 30	7 21	15·6	12 6	17 30	22
Feb. 10	3 21 23	17 40	37·6	22 20	5 58	13 36	13 36 55	7 17	16·2	10 47	16 12	21
Mar. 2	3 30 25	18 18	35·2	21 6	4 49	12 32	13 34 46	6 59	16·6	9 23	14 51	20
22	3 43 21	19 6	34·0	19 55	3 43	11 31	13 20 29	6 31	17·0	7 57	13 28	18
Apr. 11	3 59 12	19 58	32·6	18 46	2 40	10 34	13 24 58	5 56	17·2	6 34	12 4	17
May 1	4 17 8	20 49	31·9	17 40	1 39	9 38	13 19 24	5 24	17·0	5 5	10 40	16
21	4 36 22	21 34	31·2	16 36	0 40	8 44	13 14 54	5 0	16·8	3 40	9 17	14
June 10	4 56 12	22 11	31·0	15 30	23 38	7 46	13 12 19	4 49	16·2	2 18	7 56	13
30	5 15 56	22 38	31·3	14 27	22 39	6 51	13 12 6	4 54	15·8	1 0	6 37	12
July 20	5 34 51	22 55	31·8	13 25	21 39	5 53	13 14 18	5 13	15·2	23 45	5 21	10
Aug. 9	5 52 13	23 3	33·0	12 23	20 38	4 53	13 18 44	5 44	14·8	22 32	4 6	9 4
29	6 7 8	23 4	34·0	11 19	19 34	3 49	13 25 3	6 26	14·2	21 23	2 54	8 2
Sept. 18	6 18 38	23 1	35·6	10 11	18 26	2 41	13 32 48	7 15	14·0	20 18	1 43	7
Oct. 8	6 25 42	22 59	38·0	9 1	17 15	1 29	13 41 30	8 7	13·8	19 12	0 33	5 5
28	6 27 24	22 59	40·2	7 44	15 58	0 13	13 50 37	8 59	13·8	18 3	23 20	4 3
Nov. 17	6 23 23	23 3	42·6	6 20	14 35	22 49	13 59 38	9 47	14·0	16 57	22 10	3 2
Dec. 7	6 14 26	23 9	44·0	4 52	13 7	21 22	14 7 55	10 29	14·2	15 51	21 0	2
27	6 2 53	23 14 N.	44·4	3 21	11 37	19 53	14 14 54	11 2 S.	14·6	14 42	19 48	0 5

Uranus (♅).

Neptune (♆).

Jan. 1	14 47 57	15 46 S.	3·7	15 20	20 0	0 40	4 40 17	20 37 N.	2·7	1 56	9 54	17 5
31	14 51 25	16 1	3·7	13 27	18 6	22 45	4 38 1	20 34	2·6	23 57	7 54	15 5
Mar. 2	14 51 44	16 2	3·8	11 30	16 8	20 46	4 37 42	20 35	2·6	21 59	5 56	13 5
Apr. 1	14 49 1	15 51	3·8	9 26	14 7	18 48	4 39 30	20 40	2·6	19 58	3 59	11 5
May 1	14 44 24	15 29	3·8	7 23	12 5	16 47	4 43 3	20 48	2·5	18 6	2 5	10 4
31	14 39 37	15 8	3·8	5 13	10 2	14 51	4 47 36	20 57	2·5	16 11	0 11	8 11
June 30	14 36 26	14 54	3·7	3 15	8 1	12 47	4 52 16	21 5	2·5	14 14	22 15	6 16
July 30	14 36 0	14 53	3·7	1 13	5 59	10 55	4 56 10	21 10	2·5	12 18	20 20	4 20
Aug. 29	14 38 31	15 5	3·6	23 18	4 7	9 26	4 58 34	21 13	2·6	10 23	18 25	2 27
Sept. 28	14 43 41	15 30	3·6	21 32	2 14	6 56	4 58 57	21 12	2·6	8 25	16 27	0 29
Oct. 28	14 50 34	16 1	3·5	19 44	0 23	5 2	4 57 17	21 9	2·7	6 27	14 28	22 29
Nov. 27	14 57 58	16 33	3·4	17 54	22 29	3 4	4 54 8	21 3	2·7	4 26	12 27	20 28
Dec. 27	15 4 32	17 [illegible] S.	3·5	15 5	20 38	1 11	4 50 36	20 58 N.	2·7	2 25	10 25	18 25

Juno.

1894.	R.A. Noon.	Dec. Noon.	Transits.	1894.	R.A. Noon.	Dec. Noon.	Transits.
	h m	° ′	h m		h m	° ′	h m
Jan. 2 ...	14 44	8 46 S.	19 53	July 13 ...	14 31	0 58 S.	7 5
26 ...	15 7	9 3	18 41	Aug. 18 ...	14 48	3 58	5 0
Feb. 19 ...	15 22	8 22	17 22	Sept. 11 ...	15 9	6 16	3 47
Mar. 15 ...	15 26	6 41	15 51	Oct. 5 ...	15 35	8 32	2 38
Apr. 8 ...	15 19	4 15	14 9	29 ...	16 4	10 30	1 33
May 2 ...	15 2	1 44	12 18	Nov. 22 ...	16 37	12 0	0 31
26 ...	14 43	0 7 S.	10 25	Dec. 16 ...	17 10	12 55 S.	23 27
June 19 ...	14 32	0 5 N.	8 40				

ECLIPSES IN 1894.

In the year 1894 there will be two Eclipses of the Sun and two of the Moon.

I.—*A Partial Eclipse of the Moon, March* 20–21.

Invisible at Greenwich. The Moon will be seen in the shadow in longitudes from 18^h to 2^h E. Magnitude of Eclipse (Moon's diameter = 1) 0·244.

Greenwich M.T. of ☍ in R.A.: Mar. $21^d\ 1^h\ 27^m\ 18^s{\cdot}7$.

II.—*An Annular Eclipse of the Sun, April* 5.

Just visible as a partial eclipse in Norway and Sweden, Eastern Europe, and Asia. As a central eclipse, along a line beginning on the Indian Ocean, crossing India north of Madras, passing through Calcutta, Upper Burmah, China, and Eastern Siberia.

Greenwich M:T. of ☌ in R.A.: April $5^d\ 16^h\ 27^m\ 39^s{\cdot}2$.

⊙'s and ☾'s R.A. $1^h\ 0^m\ 16^s{\cdot}93$. Hourly motions $9^s{\cdot}13$ and $121^s{\cdot}27$.

	°	′	″		′	″
⊙'s Declination	6	26	11·6 N.	Hourly motion	0	56·7 N.
☾'s Declination	7	3	48·6 N.	Hourly motion	15	53·7 N.
⊙'s Equat. Hor. Parallax			8·8	True Semidiameter...	16	0·6
☾'s Equat. Hor. Parallax		57	52·5	True Semidiameter ...	15	47·8

		d	h	m		°	′		°	′	
Eclipse begins ...	April	5	13	16·0	G. M. T. in Long.	72	21	E., Lat.	6	31	S.
Eclipse ends		5	18	13·7		179	41	E.,	49	46	N.

III.—*A Partial Eclipse of the Moon, Sept.* 14.

Partly visible at Greenwich. The first contact with the shadow occurs *at* the North Point, the last at 58° to the W. of N. Point (for *direct* image).

		d	h	m		m	s
First contact with Penumbra	Sept.	14	14	0·5	Shadow	15	36·2
Second contact with Penumbra......		14	19	2·7		17	27·0

Magnitude of the Eclipse (Moon's diameter = 1) 0·225.
At Greenwich the Moon will set at $17^h\ 39^m$.

IV.—*A Total Eclipse of the Sun, Sept.* 28.

The path of the centre of the shadow of this Eclipse lies entirely across the Southern Indian Ocean, and apparently through the Amirante Islands; but as the maximum duration of totality is only 11 sec., the phenomenon is of little interest. The penumbra will pass over South-western Australia a short time before sunset, the Sun being seen at Melbourne partially eclipsed just before setting.

TRANSIT OF MERCURY.

There will be a Transit of Mercury on Nov. 10, the first contact being visible at Greenwich just before Sunset.

Ingress.		d	h	m	s	Egress.	h	m	s
External Contact......	Nov.	10	3	55	40	External Contact......	9	13	9
Internal Contact		10	3	57	23	Internal Contact	9	11	26

Sun in Zenith at Ingress 63° W., 17° S.; at Egress 142° W., 17° S.

OCCULTATIONS, 1894. (VISIBLE AT GREENWICH.)

Date.	Star.	Mag.	Disap.		Reap.	
			M.T.	P.	M.T.	P.
Jan.			h m	°	h m	°
2	B.A.C. 5286	6½	16 50†	119	17 58	292
12	24 Piscium.	6½	7 3	93	7 56	197
16	ζ Arietis ...	4½	9 23	351	9 40	324
16	τ^1 Arietis...	5	11 56	94	12 53	237
18	B.A.C. 1746	6½	15 13	29	15 37	337
19	49 Aurigæ..	5½	11 9	35	11 43	337
20	*c* Geminor..	6	11 10	128	12 15	260
27	B.A C. 4679	6½	15 25	73	16 11	358
29	42 Libræ ...	5½	14 41†	112	15 49	302
29	B.A.C. 5197	6	18 54	183	19 25	226
Feb.						
9	44 Piscium.	6	6 37	3	7 16	291
13	36 Tauri ...	6	12 38	128	13 15	216
17	λ Cancri ...	6	11 5	108	12 13	296
19	37 Leonis...	6	9 59	148	11 0	271
28	B.A.C. 6107	4	17 13	138	18 16	236
Mar.						
16	ω^2 Cancri...	6½	12 3	88	12 58	314
22	α Virginis...	1	16 5	123	17 13	297
23	B.A.C. 4700	6	13 47	109	15 1	318
25	2 Scorpii ...	5	14 32	125	15 52	282
25	B.A.C. 5255	6	14 58	130	16 17	275
25	3 Scorpii ...	6	15 6	85	16 19	320
Apr.						
1	29 Aquarii .	6	16 19†	66	17 27	251
9	χ^1 Tauri ...	5½	7 4	67	8 4	278
10	B.A.C. 1746	6½	10 54	92	11 44	273
11	49 Aurigæ .	5½	8 40	76	9 37	305
12	*c* Geminor. .	6	10 52	111	11 49	286
16	σ Leonis ...	4	8 42	78	9 29	357
18	B.A.C. 4394	6	16 28	106	17 25†	306
28	κ Capricor. .	5	15 2	53	16 13	264
May						
12	37 Leonis...	6	7 55	88	8 51	340
14	B.A.C. 4043	6½	10 36	76	11 21	355
15	B.A.C 4294	6½	11 50	120	12 58	305
18	B.A.C. 5023	6	14 19	46	14 53	350
19	B.A.C. 5314	6	10 58	134	12 14	271
19	B.A.C. 5347	5	14 20	164	14 59	223
30	ξ^1 Piscium .	4½	13 56*	96	14 40	207
June						
12	ς8 Virginis .	6	9 0	187	9 37	246
14	B.A.C. 4923	6	11 20	175	11 57	232
15	B.A.C. 5197	6	9 2	108	10 23	300
19	B.A.C. 6628	6	10 46	89	12 8	267
July						
17	A Sagittarii	5	8 42	55	9 52	286
20	50 Aquarii .	6	10 33	354	10 57	315
20	B.A.C. 7835	6½	14 1	47	15 20	241
25	19 Arietis...	6	11 30	60	12 25	243
26	ζ Arietis ...	4½	15 40	117	16 18	186
27	36 Tauri ...	6	11 51	126	12 20	197

Date.	Star.	Mag.	Disap.		Reap
			M.T.	P.	M.T.
Aug.			h m	°	h m
6	α Virginis...	1	0 59	53	1 19
6	B.A.C. 4531	6	7 41	153	8 38
9	B.A.C. 5347	5	8 6	66	9 10
18	20 Piscium .	[illegible]	15 5	98	15 57
19	44 Piscium .	6	10 6	111	10 45
23	27 Tauri ...	4	13 2	9	13 35
Sept.					
9	B.A.C. 6628	6	6 5	37	7 4
11	φ Capricor. .	5½	12 43	72	13 50‡
13	70 Aquarii .	6	13 17	88	14 16
16	ε Piscium...	4	14 6	353	14 43
19	9 Tauri ...	6	13 28	84	14 37
20	χ^1 Tauri ...	5½	8 4	52	8 49
23	*c* Geminor..	6	12 41	81	13 34
Oct.					
7	A Sagittarii.	5	6 33	1	7 1
10	50 Aquarii .	6	7 14	30	8 25
10	B.A.C. 7835	6½	11 11	102	11 58
14	π Piscium .	6	14 45	36	15 47
15	19 Arietis . .	6	5 53	113	6 27
15	27 Arietis . .	6	16 13	115	16 58
16	66 Arietis...	6½	17 27	73	18 31
18	B.A.C. 1648	6½	12 34	45	13 33
19	49 Aurigæ .	5½	17 15	93	18 29
Nov.					
7	70 Aquarii .	6	4 29	42	5 42
13	27 Tauri ...	4	8 29	21	9 14
13	28 Tauri ...	5½	8 50	347	9 3
15	136 Tauri...	5	7 9	119	7 50
16	47 Geminor.	6	12 3	119	13 6
19	34 Leonis...	6	14 0	159	14 46
Dec.					
8	π Piscium...	6	9 8	55	10 23
9	27 Arietis...	6	10 50	136	11 13
10	66 Arietis...	6½	11 17	70	12 29
10	9 Tauri......	6	15 27	95	16 22
11	χ^1 Tauri ...	5½	7 24	88	8 25
12	B.A.C. 1746	6½	11 14	152	11 42
12	136 Tauri...	5	18 30	118	19 18
15	γ Cancri ...	4½	7 3	120	7 50
18	89 Leonis...	6	10 47†	63	11 19*
19	B.A.C. 4200	6	13 37	159	14 25
19	B.A.C. 4225	6½	15 33	124	16 42
19	*f* Virginis...	6	19 4	84	19 57
23	π Scorpii...	3	19 9	150	20 9
31	45 Aquarii	6	5 46	55	6 57

* Star rising. ‡ Star setting. † Star below horizon.

The angles (P) are reckoned from the true N. point in the direction N., E., S., W., *i. e.* from the bottom of the Moon's inverted image towards the right.

The following "near approaches" are also given in the 'Nautical Almanac,' and are especially interesting to observers rather South and rather North of Greenwich respectively:—

North Near Approaches.

Date.	Star.		G.M.T.	Angle.	Date.	Star.	Mag.	G.M.T.	Angle.
Mar.			h m	°	Sept.			h m	°
16	ω¹ Cancri ...	6	12 2	21	4	B.A.C. 4923 .	6	8 21	17
20	β Virginis ...	3½	17 24	29	11	χ Capricor. .	6	8 45	335
June					18	27 Arietis ...	6	8 16	334
13	B.A.C. 4700 .	6	12 41	23	19	66 Arietis ...	6½	9 59	336
July					22	49 Aurigæ ...	5½	11 10	356
18	B.A.C. 7197 .	6	8 55	346					
Aug.					Nov.				
23	23 Tauri......	5	12 5	337	13	23 Tauri ...	5	7 38	336
23	28 Tauri......	5½	13 22	336	13	η Tauri	3	8 9	336

South Near Approaches.

Date.	Star.		G.M.T.	Angle.	Date.	Star.	Mag.	G.M.T.	Angle.
Jan.			h m	°	Oct.			h m	°
26	α Virginis ...	1	21 47	207	17	χ¹ Tauri.....	5½	15 5	165
Feb.					18	B.A.C. 1746 .	6½	20 17	184
16	47 Geminor .	6	9 48	190					
21	B.A.C. 4043 .	6½	10 3	212					
Mar.					Nov.				
14	136 Tauri ...	5	12 25	185	23	B.A.C. 4531 .	6	17 57	214
Aug.									
25	136 Tauri ...	5	13 4	171	Dec.				
Sept.					4	B.A.C. 7835 .	6½	3 6	148
6	B.A.C. 5603 .	6½	9 3	184	10	ζ Arietis ...	4½	4 30	155
21	B.A.C. 1746 .	6½	12 48	168	21	B.A.C. 4722 .	6	20 40	212

CONFIGURATIONS OF JUPITER'S SATELLITES

FOR AN INVERTING TELESCOPE.

Day.	Jan. 10^{h}	Feb. 9^{h}	March. 8^{h}	April. 8^{h}	May. 8^{h}.	July. 15^{h}	Aug. 15^{h}	Sept. 14^{h}	Oct. 14^{h}	Nov. 13^{h}	Dec. 12^{h}	Day.
1	12O34	3O124	♃41O2	432O1	O142●	♃13O4	34O12	421O3	41O23	3O214	♃3O14	1
2	2O134	312O4	43O12	431O2	124O3	♃32O4	4O2●●	♃4O23	42O31	31O42	21O4●	2
3	13O24	32O14	324O●	♃4O23	42O13	3O124	21O43	4O123	432O●	♃234O	O1234	3
4	3O412	1O324	312O4	42O13	4O23●	31O24	O2134	2431O	431O2	42O13	O234●	4
5	3241O	O1234	O1324	412O3	431O2	2O134	1O234	3O421	43O21	41O23	21O34	5
6	423O1	21O43	12O34	43O12	432O1	12O34	23O14	31O24	421O3	4O213	324O1	6
7	4O23●	42O13	2O134	312O4	4312O	O1243	321O4	23O14	4O213	♃421O	341O2	7
8	412O3	43O2●	1O324	32O14		♃14O2	3O124	21O34	14O23	43O21	43O21	8
9	42O13	♃431O	3O124	31O24		342O1	31O24	O1234	2O134	431O2	4213O	9
10	413O2	432O1	321O4	O1234		43O2●	♃2O43	O234●	32O4●	432O1	4O213	10
11	43O12	41O2●	♃32O4	2O34●		431O2	4O13●	231O4	♃3O24	2O43●	41O23	11
12	3214O	4O123	O4132	21O34		42O13	41O23	3O14●	3O124	1O243	♃42O3	12
13	23O14	421O3	♃41O3	O3124		421O3	423O1	31O42	21O34	O2134	423O1	13
14	1O324	42O13	42O13	♃31O4		4O123	4321O	42O1●	O134●	21O34	314O2	14
15	♃♃O34	3O42●	41O32	324O1		41O32	43O12	421O3	1O234	3O14●	3O214	15
16	2O134	31O24	43O12	431O2		324O1	431O2	4O123	2O134	31O24	213O4	16
17	13O24	32O14	4321O	4O132		3O4●●	42O13	4O23●	2314O	32O14	O134●	17
18	3O124	13O24	♃432O	42O3●		♃3O24	4O13●	♃423O	34O12	2O34●	1O234	18
19	321O4	O1234	4O32●	421O3		2O134	14O23	43O1●	43O12	1O423	♃2O34	19
20	32O14	21O34	41O23	4O312		21O34	2O314	431O2	4213O	4O123	23O14	20
21	14O32	2O134	2O413	431O2		O1234	321O4	432O1	4O13●	421O3	31O24	21
22	4O123	31O24	1O34●	342O1		1O324	3O124	21O43	41O23	43O1●	3O421	22
23	42O3●	♃3O24	3O124	314O●		23O14	31O24	O1243	42O13	431O2	2143O	23
24	41O3●	324O1	321O4	O3142		312O4	2O134	1O234	4231O	432O1	4O13●	24
25	43O12	413O2	32O14	21O34		♃34O2	2O34●	♃♃2O4	34O12	421O3	41O23	25
26	4312O	4O132	3O24●	♃2O34		42O1●	1O234	32O14	3O24●	♃4O23	42O13	26
27	432O1	412O3	1O234	O1324		421O3	♃O314	31O24	21O4●	4O123	♃42O●	27
28	41O32	42O13	2O143	31O24		4O213	3214O	♃3O14	2O134	21O43	431O2	28
29	4O123		1O43●	32O14		41O32	34O21	21O34	1O234	32O14	43O12	29
30	21O43		43O12	31O4●		423O1	431O2	O4213	♃O134	31O24	2431O	30
31	1O34●		4312O			4312O	42O31		213O4		2O431	31

The circle (O) represents Jupiter; ♃ signifies that the satellite is on the disk; ● signifies that the satellite is behind the disk or in the shadow.

East Elongations.

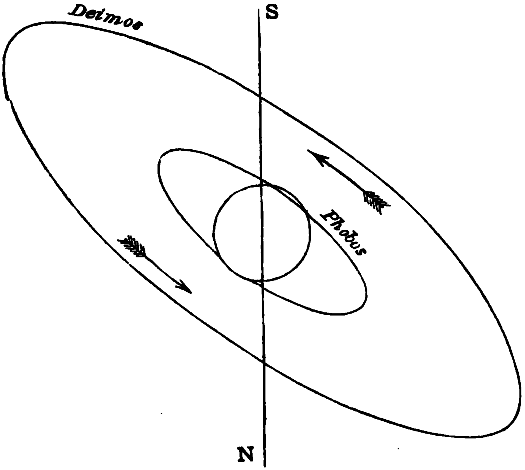
Phobos.

September.		October.		Oct. (*con.*).		Oct. (*con.*).		Oct. (*con.*).		Nov. (*con.*).	
d	h	d	h	d	h	d	h	d	h	d	h
25	1·4	1	10·4	10	8·7	19	6·9	28	5·2	3	14·3
25	16·7	2	1·7	11	0·0	19	22·2	28	20·5	4	5·6
26	8·0	2	17·1	11	15·3	20	13·6	29	11·9	4	20·9
26	23·3	3	8·4	12	6·6	21	4·9	30	3·2	5	12·2
27	14·6	3	23·7	12	21·9	21	20·2	30	18·5	6	3·5
28	5·9	4	15·0	13	13·2	22	11·5	31	9·8	6	18·8
28	21·2	5	6·3	14	4·5	23	2·8			7	10·1
29	12·5	5	21·6	14	19·8	23	18·1			8	1·4
30	3·8	6	12·9	15	11·1	24	9·3	November.		8	16·7
30	19·1	7	4·2	16	2·4	25	0·7			9	8·0
		7	19·5	16	17·7	25	16·0	1	1·1	9	23·3
		8	10·8	17	9·0	26	7·3	1	16·4	10	14·6
		9	2·1	18	0·3	26	22·6	2	7·7	11	5·9
		9	17·4	18	15·6	27	13·9	2	23·0		

Deimos.

September.		October.		Oct. (*con.*).		Oct. (*con.*).		November.		Nov. (*con.*).	
d	h	d	h	d	h	d	h	d	h	d	h
25	23·7	1	0·7	12	9·3	23	17·8	1	13·7	12	22·1
27	6·0	2	7·0	13	15·6	25	0·0	2	19·9	14	4·4
28	12·3	3	13·3	14	21·8	26	6·3	4	2·2	15	10·7
29	18·5	4	19·6	16	4·1	27	12·6	5	8·4	16	16·9
		6	1·8	17	10·3	28	18·9	6	14·7	17	23·1
		7	8·1	18	16·6	30	1·1	7	21·0		
		8	14·4	19	22·9	31	7·4	9	3·3		
		9	20·7	21	5·2			10	9·6		
		11	3·0	22	11·5			11	15·9		

For Phobos the alternate East Elongations only are given



Apparent Orbits of the Satellites of Mars during the Opposition of 1894, as seen in an inverting telescope.

The circle represents the disk of the planet, and is on the same scale as the orbits. The mean motions of the satellites have been corrected by the observations made during the oppositions of 1888 and 1890.

Apparent Disk of Mars.

Jan. 1	0·957	May 31	0·852	Sept. 28	0·970
31	0·934	June 30	0·841	Oct. 28	0·997
Mar. 2	0·910	July 30	0·853	Nov. 27	0·944
April 1	0·885	Aug. 29	0·892	Dec. 27	0·901
May 1	0·863				

The numbers in this table are the versed sines of the illuminated disk, the apparent diameter of the planet being taken as unity.

JUPITER'S SATELLITES, 1894.

Phenomena.

e, Signifies Ec. dis.; E, Ec. re.; *o*, Occ. dis.; O, Occ. re.; *t*, Tr. Ing.; T, Tr. Egr.

d	h	m	
January.			
1	5	24	i. *t*.
	7	36	i. T.
2	2	38	i. *o*.
	5	50	i. E.
	23	11	iii. *t*.
	23	27	ii. *o*.
	23	51	i. *t*.
3	0	57	iii. T.
	2	3	i. T.
	3	47	ii. E.
	21	5	i. *o*.
4	0	19	i. E.
	18	7	ii. *t*.
	18	18	i. *t*.
	20	28	ii. T.
	20	30	i. T.
5	15	33	i. *o*.
	18	48	i. E.
6	12	38	ii. *o*.
	12	45	i. *t*.
	12	48	iii. *o*.
	14	37	iii. O.
	14	58	i. T.
	17	5	ii. E.
	17	18	iii. *e*.
	18	57	iii. E.
7	10	0	i. *o*.
	13	17	i. E.
8	7	13	i. *t*.
	7	21	ii. *t*.
	9	25	i. T.
	9	42	ii. T.
9	4	28	i. *o*.
	7	46	i. E.
10	1	40	i. *t*.
	1	50	ii. *o*.
	2	46	iii. *t*.
	3	53	i. T.
	4	36	iii. T.
	6	23	ii. E.
	22	55	i. *o*.
11	2	14	i. E.
	20	8	i. *t*.
	20	35	ii. *t*.
	22	20	i. T.
	22	56	ii. T.
12	17	23	i. *o*.
	20	43	i. E.
13	14	35	i. *t*.
	15	3	ii. *o*.
	16	26	iii. *o*.
	16	48	i. T.
	17	25	ii. O.
	17	26	ii. *e*.
Jan. (con.).			
13	18	19	iii. O.
	19	41	ii. E.
	21	20	iii. *e*.
	22	59	iii. E.
14	11	51	i. *o*.
	15	12	i. E.
15	9	3	i. *t*.
	9	50	ii. *t*.
	11	16	i. T.
	12	11	ii. T.
16	6	19	i. *o*.
	9	41	i. E.
17	3	31	i. *t*.
	4	16	ii. *o*.
	5	43	i. T.
	6	27	iii. *t*.
	6	38	ii. O.
	6	44	ii. *e*.
	8	21	iii. T.
	8	59	ii. E.
18	0	46	i. *o*.
	4	10	i. E.
	21	58	i. *t*.
	23	4	ii. *t*.
19	0	11	i. T.
	1	26	ii. T.
	19	14	i. *o*.
	22	39	i. E.
20	16	26	i. *t*.
	17	30	ii. *o*.
	18	39	i. T.
	19	53	ii. O.
	20	2	ii. *e*.
	20	10	iii. *o*.
	22	5	iii. O.
	22	17	ii. E.
21	1	21	iii. *e*.
	3	1	iii. E.
	13	42	i. *o*.
	17	8	i. E.
22	10	54	i. *t*.
	12	20	ii. *t*.
	13	7	i. T.
	14	43	ii. T.
23	8	11	i. *o*.
	11	37	i. E.
24	5	22	i. *t*.
	6	45	ii. *o*.
	7	35	i. T.
	9	7	ii. O.
	9	20	ii. *e*.
	10	13	iii. *t*.
	11	35	ii. E.
	12	10	iii. T.
Jan. (con.).			
25	2	39	i. *o*.
	6	6	i. E.
	23	50	i. *t*.
26	1	36	ii. *t*.
	2	3	i. T.
	3	58	ii. T.
	21	7	i. *o*.
27	0	35	i. E.
	18	19	i. *t*.
	20	0	ii. *o*.
	20	31	i. T.
	22	23	ii. O.
	22	37	ii. *e*.
	23	58	iii. *o*.
28	0	53	ii. E.
	1	57	iii. O.
	5	22	iii. *e*.
	7	4	iii. E.
	15	36	i. *o*.
	19	4	i. E.
29	12	47	i. *t*.
	14	54	ii. *t*.
	15	0	i. T.
	17	17	ii. T.
30	10	4	i. *o*.
	13	33	i. E.
31	7	15	i. *t*.
	9	16	ii. *o*.
	9	28	i. T.
	11	39	ii. O.
	11	55	ii. *e*.
	14	4	iii. *t*.
	14	11	ii. E.
	16	4	iii. T.
February.			
1	4	33	i. *o*.
	8	2	i. E.
2	1	44	i. *t*.
	3	57	i. T.
	4	11	ii. *t*.
	6	34	ii. T.
	23	1	i. *o*.
3	2	31	i. E.
	20	12	i. *t*.
	22	25	i. T.
	22	32	ii. *o*.
4	0	56	ii. O.
	1	13	ii. *e*.
	3	29	ii. E.
	3	52	iii. *o*.
	5	53	iii. O.
	9	23	iii. *e*.
Feb. (con.).			
4	11	6	iii. E.
	17	30	i. *o*.
	21	0	i. E.
5	14	41	i. *t*.
	16	54	i. T.
	17	29	ii. *t*.
	19	53	ii. T.
6	11	59	i. *o*.
	15	29	i. E.
7	9	9	i. *t*.
	11	22	i. T.
	11	49	ii. *o*.
	14	13	ii. O.
	14	31	ii. *e*.
	16	47	ii. E.
	18	0	iii. *t*.
	20	2	iii. T.
8	6	27	i. *o*.
	9	58	i. E.
9	3	38	i. *t*.
	5	51	i. T.
	6	47	ii. *t*.
	9	11	ii. T.
10	0	56	i. *o*.
	4	27	i. E.
	22	7	i. *t*.
11	0	20	i. T.
	1	7	ii. *o*.
	3	31	ii. O.
	3	49	ii. *e*.
	6	5	ii. E.
	7	51	iii. *o*.
	9	54	iii. O.
	13	25	iii. *e*.
	15	9	iii. E.
	19	25	i. *o*.
	22	56	i. E.
12	16	35	i. *t*.
	18	49	i. T.
	20	7	ii. *t*.
	22	31	ii. T.
13	13	54	i. *o*.
	17	25	i. E.
14	11	4	i. *t*.
	13	18	i. T.
	14	25	ii. *o*.
	16	49	ii. O.
	17	7	ii. *e*.
	19	23	ii. E.
	21	59	iii. *t*.
15	0	4	iii. T.
	8	23	i. *o*.
	11	54	i. E.
16	5	33	i. *t*.
Feb. (con.).			
16	7	47	i. T.
	9	26	ii. *t*.
	11	50	ii. T.
17	2	52	i. *o*.
	6	23	i. E.
18	0	2	i. *t*.
	2	16	i. T.
	3	43	ii. *o*.
	6	8	ii. O.
	6	25	ii. *e*.
	8	41	ii. E.
	11	54	iii. *o*.
	14	0	iii. O.
	17	26	iii. *e*.
	19	11	iii. E.
	21	22	i. *o*.
19	0	52	i. E.
	18	32	i. *t*.
	20	45	i. T.
	22	46	ii. *t*.
20	1	11	ii. T.
	15	51	i. *o*.
	19	21	i. E.
21	13	1	i. *t*.
	15	14	i. T.
	17	2	ii. *o*.
	19	27	ii. O.
	19	43	ii. *e*.
	22	0	ii. E.
22	2	4	iii. *t*.
	4	10	iii. T.
	10	20	i. *o*.
	13	50	i. E.
23	7	30	i. *t*.
	9	43	i. T.
	12	6	ii. *t*.
	14	31	ii. T.
24	4	49	i. *o*.
	8	19	i. E.
25	1	59	i. *t*.
	4	13	i. T.
	6	22	ii. *o*.
	8	47	ii. O.
	9	1	ii. *e*.
	11	18	ii. E.
	16	1	iii. *o*.
	18	8	iii. O.
	21	28	iii. *e*.
	23	14	iii. E.
	23	19	i. *o*.
26	2	48	i. E.
	20	29	i. *t*.
	22	42	i. T.
27	1	27	ii. *t*.
Feb. (con.).			
27	3	52	ii. T.
	17	48	i. *o*.
	21	17	i. E.
28	14	58	i. *t*.
	17	11	i. T.
	19	42	ii. *o*.
	22	7	ii. O.
	22	20	ii. *e*.
March.			
1	0	36	ii. E.
	6	13	iii. *t*.
	8	20	iii. T.
	12	18	i. *o*.
	15	46	i. E.
2	9	27	i. *t*.
	11	41	i. T.
	14	48	ii. *t*.
	17	13	ii. T.
3	6	47	i. *o*.
	10	15	i. E.
4	3	57	i. *t*.
	6	10	i. T.
	9	3	ii. *o*.
	11	28	ii. O.
	11	38	ii. *e*.
	13	54	ii. E.
	20	12	iii. *o*.
	22	20	iii. O.
5	1	17	i. *o*.
	1	29	iii. *e*.
	3	16	iii. E.
	4	43	i. E.
	22	26	i. *t*.
6	0	40	i. T.
	4	10	ii. *t*.
	6	35	ii. T.
	19	47	i. *o*.
	23	12	i. E.
7	16	56	i. *t*.
	19	9	i. T.
	22	24	ii. *o*.
8	0	49	ii. O.
	0	56	ii. *e*.
	3	13	ii. E.
	10	26	iii. *t*.
	12	34	iii. T.
	14	16	i. *o*.
	17	41	i. E.
9	11	26	i. *t*.
	13	39	i. T.
	17	32	ii. *t*.

Mar. (con.).

d	h	m	
9	19	57	ii. T.
10	8	46	i. *o.*
	12	10	i. E.
11	5	55	i. *t.*
	8	9	i. T.
	11	45	ii. *o.*
	14	11	ii. O.
	14	14	ii. *e.*
	16	31	ii. E.
12	0	26	iii. *o.*
	2	35	iii. O.
	3	16	i. *o.*
	5	29	iii. *e.*
	6	39	i. E.
	7	18	iii. E.
13	0	25	i. *t.*
	2	39	i. T.
	6	54	ii. *t.*
	9	20	ii. T.
	21	46	i. *o.*
14	1	8	i. E.
	18	55	i. *t.*
	21	8	i. T.
15	1	7	ii. *o.*
	3	32	ii. O.
	3	32	ii. *e.*
	5	49	ii. E.
	14	41	iii. *t.*
	16	15	i. *o*
	16	51	iii. T.
	19	37	i. E.
16	13	25	i. *t.*
	15	38	i. T.
	20	16	ii. *t.*
	22	42	ii. T.
17	10	45	i. *o.*
	14	6	i. E.
18	7	54	i. *t.*
	10	8	i. T.
	14	29	ii. *o.*
	19	8	ii. E.
19	4	43	iii. *o.*
	5	15	i. *o.*
	6	53	iii. O.
	8	35	i. E.
	9	30	iii. *e.*
	11	20	iii. E.
20	2	24	i. *t.*
	4	38	i. T.
	9	40	ii. *t.*
	12	5	ii. T.
	23	45	i. *o.*
21	3	4	i. E.
	20	54	i. *t.*
	23	8	i. T.
22	3	51	ii. *o.*
	8	26	ii. E.
	18	15	i. *o.*
	18	59	iii. *t.*
	21	10	iii. T.
	21	33	i. E.
23	15	24	i. *t.*
	17	38	i. T.
	23	2	ii. *t.*

Mar. (con.).

d	h	m	
24	1	28	ii. T.
	12	45	i. *o.*
	16	2	i. E.
25	9	54	i. *t.*
	12	8	i. T.
	17	14	ii. *o.*
	21	45	ii. E.
26	7	15	i. *o.*
	9	3	iii. *o.*
	10	30	i. E.
	11	14	iii. O.
	13	31	iii. *e.*
	15	22	iii. E.
27	4	24	i. *t.*
	6	38	i. T.
	12	26	ii. *t.*
	14	52	ii. T.
28	1	45	i. *o.*
	4	59	i. E.
	22	54	i. *t.*
29	1	8	i. T.
	6	37	ii. *o.*
	11	3	ii. E.
	20	16	i. *o.*
	23	20	iii. *t.*
	23	28	i. E.
30	1	32	iii. T.
	17	24	i. *t.*
	19	38	i. T.
31	1	50	ii. *t.*
	4	16	ii. T.
	14	46	i. *o.*
	17	57	i. E.

April.

d	h	m	
1	11	54	i. *t.*
	14	8	i. T.
	20	1	ii. *o.*
2	0	22	ii. E.
	9	16	i. *o.*
	12	26	i. E.
	13	25	iii. *o.*
	15	37	iii. O.
	17	32	iii. *e.*
	19	25	iii. E.
3	6	24	i. *t.*
	8	38	i. T.
	15	14	ii. *t.*
	17	40	ii. T.
4	3	46	i. *o.*
	6	55	i. E.
5	0	55	i. *t.*
	3	8	i. T.
	9	24	ii. *o.*
	13	40	ii. E.
	22	16	i. *o.*
6	1	23	i. E.
	3	42	iii. *t.*
	5	55	iii. T.
	19	25	i. *t.*
	21	39	i. T.
7	4	37	ii. *t.*
	7	4	ii. T.

Apr. (con.).

d	h	m	
7	16	46	i. *o.*
	19	52	i. E.
8	13	55	i. *t.*
	16	9	i. T.
	22	48	ii. *o.*
9	2	59	ii. E.
	11	17	i. *o.*
	14	21	i. E.
	17	48	iii. *o.*
	20	2	iii. O.
	21	33	iii. *e.*
	23	27	iii. E.
10	8	25	i. *t.*
	10	39	i. T.
	18	2	ii. *t.*
	20	28	ii. T.
11	5	47	i. *o.*
	8	50	i. E.
12	2	56	i. *t.*
	5	9	i. T.
	12	13	ii. *o.*
	16	17	ii. E.
13	0	17	i. *o.*
	3	19	i. E.
	8	6	iii. *t.*
	10	20	iii. T.
	21	26	i. *t.*
	23	40	i. T.
14	7	26	ii. *t.*
	9	52	ii. T.
	18	47	i. *o.*
	21	48	i. E.
15	15	56	i. *t.*
	18	10	i. T.
16	1	37	ii. *o.*
	5	36	ii. E.
	13	18	i. *o.*
	16	16	i. E.
	22	14	iii. *o.*
17	0	28	iii. O.
	1	34	iii. *e.*
	3	29	iii. E.
	10	27	i. *t.*
	12	40	i. T.
	20	51	ii. *t.*
	23	17	ii. T.
18	7	48	i. *o.*
	10	45	i. E.
19	4	57	i. *t.*
	7	11	i. T.
	15	2	ii. *o.*
	18	54	ii. E.
20	2	18	i. *o.*
	5	14	i. E.
	12	32	iii. *t.*
	14	47	iii. T.
	23	27	i. *t.*
21	1	41	i. T.
	10	15	ii. *t.*
	12	41	ii. T.
	20	49	i. *o.*
	23	43	i. E.
22	17	58	i. *t.*
	20	12	i. T.

Apr. (con.).

d	h	m	
23	4	27	ii. *o.*
	8	13	ii. E.
	15	19	i. *o.*
	18	12	i. E.
24	2	40	iii. *o.*
	4	56	iii. O.
	5	34	iii. *e.*
	7	30	iii. E.
	12	28	i. *t.*
	14	42	i. T.
	23	40	ii. *t.*
25	2	6	ii. T.
	9	50	i. *o.*
	12	40	i. E.
26	6	58	i. *t.*
	9	12	i. T.
	17	51	ii. *o.*
	21	31	ii. E.
27	4	20	i. *o.*
	7	9	i. E.
	17	0	iii. *t.*
	19	16	iii. T.
28	1	29	i. *t.*
	3	43	i. T.
	13	5	ii. *t.*
	15	31	ii. T.
	22	50	i. *o.*
29	1	38	i. E.
	19	59	i. *t.*
	22	13	i. T.
30	7	17	ii. *o.*
	10	50	ii. E.
	17	21	i. *o.*
	20	7	i. E.

May.

d	h	m	
1	7	7	iii. *o.*
	9	24	iii. O.
	9	34	iii. *e.*
	11	31	iii. E.
	14	30	i. *t.*
	16	44	i. T.
2	2	30	ii. *t.*
	4	56	ii. T.
	11	51	i. *o.*
	14	35	i. E.
3	9	0	i. *t.*
	11	14	i. T.
	20	42	ii. *o.*
4	0	9	ii. E.
	6	22	i. *o.*
	9	4	i. E.
	21	28	iii. *t.*
	23	45	iii. T.
5	3	31	i. *t.*
	5	45	i. T.
	15	55	ii. *t.*
	18	21	ii. T.
6	0	52	i. *o.*
	3	33	i. E.
	22	1	i. *t.*
7	0	15	i. T.
	10	7	ii. *o.*

May (con.).

d	h	m	
7	13	28	ii. E.
	19	23	i. *o.*
	22	1	i. E.

July.

d	h	m	
1	9	23	iii. *t.*
	11	50	iii. T.
	14	33	ii. *t.*
	17	2	ii. T.
2	14	17	i. *t.*
	16	31	i. T.
3	8	5	ii. *e.*
	11	8	i. *e.*
	11	31	ii. O.
	13	49	i. O.
4	8	47	i. *t.*
	11	2	i. T.
	21	32	iii. *e.*
5	1	56	iii. O.
	3	57	ii. *t.*
	5	36	i. *e.*
	6	27	ii. T.
	8	19	i. O.
6	3	17	i. *t.*
	5	32	i. T.
	21	23	ii. *e.*
7	0	5	i. *e.*
	0	57	ii. O.
	2	50	i. O.
	21	48	i. *t.*
8	0	2	i. T.
	13	49	iii. *t.*
	16	18	iii. T.
	17	21	ii. *t.*
	18	33	i. *e.*
	19	51	ii. T.
	21	20	i. O.
9	16	18	i. *t.*
	18	33	i. T.
10	10	42	ii. *e.*
	13	2	i. *e.*
	14	23	ii. O.
	15	50	i. O.
11	10	48	i. *t.*
	13	3	i. T.
12	1	31	iii. *e.*
	3	42	iii. E.
	3	55	iii. *o.*
	6	25	iii. O.
	6	45	ii. *t.*
	7	30	i. *e.*
	9	15	ii. T.
	10	20	i. O.
13	5	19	i. *t.*
	7	33	i. T.
14	0	0	ii. *e.*
	1	58	i. *e.*
	3	48	ii. O.
	4	50	i. O.
	23	49	i. *t.*
15	2	4	i. T.
	18	15	iii. *t.*
	20	9	ii. *t.*

July (con.).

d	h	m	
15	20	27	i. *e.*
	20	46	iii. T.
	22	39	ii. T.
	23	20	i. O.
16	18	19	i. *t.*
	20	34	i. T.
17	13	19	ii. *e.*
	14	55	i. *e.*
	17	14	ii. O.
	17	50	i. O.
18	12	49	i. *t.*
	15	4	i. T.
19	5	30	iii. *e.*
	7	43	iii. E.
	8	20	iii. *o.*
	9	24	i. *e.*
	9	32	ii. *t.*
	10	52	iii. O.
	12	3	ii. T.
	12	20	i. O.
20	7	19	i. *t.*
	9	34	i. T.
21	2	37	ii. *e.*
	3	52	i. *e.*
	6	39	ii. O.
	6	50	i. O.
22	1	49	i. *t.*
	4	4	i. T.
	22	21	i. *e.*
	22	40	iii. *t.*
	22	56	ii. *t.*
23	1	12	iii. T.
	1	20	i. O.
	1	27	ii. T.
	20	19	i. *t.*
	22	34	i. T.
24	15	57	ii *e.*
	16	49	i. *e.*
	19	50	i. O.
	20	4	ii. O.
25	14	50	i. *t.*
	17	5	i. T.
26	9	29	iii. *e.*
	11	18	i. *e.*
	11	43	iii. E.
	12	19	ii. *t.*
	12	44	iii. *o.*
	14	20	i. O.
	14	50	ii. T.
	15	17	iii. O.
27	9	20	i. *t.*
	11	35	i. T.
28	5	14	ii. *e.*
	5	46	i. *e.*
	8	50	i. O.
	9	29	ii. O.
29	3	50	i. *t.*
	6	5	i. T.
30	0	14	i. *e.*
	1	41	ii. *t.*
	3	3	iii. *t.*
	3	20	i. O.
	4	13	ii. T.
	5	37	iii. T.

July (con.).

d	h	m	
30	22	20	i. *t.*
31	0	35	i. T.
	18	34	ii. *e.*
	18	43	i. *e.*
	21	50	i. O.
	22	53	ii. O.

August.

d	h	m	
1	16	50	i. *t.*
	19	5	i. T.
2	13	11	i. *e.*
	13	28	iii. *e.*
	15	4	ii. *t.*
	15	43	iii. E.
	16	20	i. O.
	17	6	iii. *o.*
	17	36	ii. T.
	19	40	iii. O.
3	11	19	i. *t.*
	13	35	i. T.
4	7	40	i. *e.*
	7	51	ii. *e.*
	10	49	i. O.
	12	18	ii. O.
5	5	49	i. *t.*
	8	5	i. T.
6	2	8	i. *e.*
	4	26	ii. *t.*
	5	19	i. O.
	6	58	ii. T.
	7	26	iii. *t.*
	10	1	iii. T.
7	0	19	i. *t.*
	2	34	i. T.
	20	36	i. *e.*
	21	11	ii. *e.*
	23	49	i. O.
8	1	42	ii. O.
	18	49	i. *t.*
	21	4	i. T.
9	15	5	i. *e.*
	17	26	iii. E.
	17	48	ii. *t.*
	18	19	i. O.
	19	43	iii. E.
	20	21	ii. T.
	21	26	iii. *o.*
10	0	2	iii. O.
	13	19	i. *t.*
	15	34	i. T.
11	9	33	i. *e.*
	10	28	ii. *e.*
	12	48	i. O.
	15	5	ii. O.
12	7	49	i. *t.*
	10	4	i. T.
13	4	1	i. *e.*
	7	10	ii. *t.*
	7	18	i. O.
	9	43	ii. T.
	11	45	iii. *t.*
	14	22	iii. T.

Aug. (con.).

d	h	m	
14	2	19	i. *t.*
	4	34	i. T.
	22	30	i. *e.*
	23	47	ii. *e.*
15	1	47	i. O.
	4	29	ii. O.
	20	48	i. *t.*
	23	3	i. T.
16	16	58	i. *e.*
	20	17	i. O.
	20	32	ii. *t.*
	21	25	iii. *e.*
	23	5	ii. T.
	23	43	iii. E.
17	1	43	iii. *o.*
	4	21	iii. O.
	15	18	i. *t.*
	17	33	i. T.
18	11	27	i. *e.*
	13	5	ii. *e.*
	14	46	i. O.
	17	52	ii. O.
19	9	47	i. *t.*
	12	3	i. T.
20	5	55	i. *e.*
	9	16	i. O.
	9	53	ii. *t.*
	12	26	ii. T.
	16	2	iii. *t.*
	18	41	iii. T.
21	4	17	i. *t.*
	6	32	i. T.
22	0	23	i. *e.*
	2	24	ii. *e.*
	3	45	i. O.
	7	15	ii. O.
	22	47	i. *t.*
23	1	2	i. T.
	18	52	i. *e.*
	22	15	i. O.
	23	14	ii. *t.*
24	1	24	iii. *e.*
	1	47	ii. T.
	3	43	iii. E.
	5	59	iii. *o.*
	8	38	iii. O.
	17	16	i. *t.*
	19	31	i. T.
25	13	20	i. *e.*
	15	42	ii. *e.*
	16	44	i. O.
	20	37	ii. O.
26	11	45	i. *t.*
	14	1	i. T.
27	7	48	i. *e.*
	11	13	i. O.
	12	35	ii. *t.*
	15	8	ii. T.
	20	16	iii. *t.*
	22	56	iii. T.
28	6	15	i. *t.*
	8	30	i. T.
29	2	17	i. *e.*
	5	1	ii. *e.*

Aug. (con.).

d	h	m	
29	5	42	i. O.
	9	59	ii. O.
30	0	44	i. *t.*
	3	0	i. T.
	20	45	i. *e.*
31	0	12	i. O.
	1	55	ii. *t.*
	4	29	ii. T.
	5	23	iii. *e.*
	7	44	iii. E.
	10	12	iii. *o.*
	12	53	iii. O.
	19	13	i. *t.*
	21	29	i. T.

September.

d	h	m	
1	15	13	i. *e.*
	18	18	ii. *e.*
	18	41	i. O.
	20	45	ii. E.
	20	47	ii. *o.*
	23	21	ii. O.
2	13	43	i. *t.*
	15	59	i. T.
3	9	42	i. *e.*
	13	10	i. O.
	15	15	ii. *t.*
	17	49	ii. T.
4	0	28	iii. *t.*
	3	9	iii. T.
	8	12	i. *t.*
	10	27	i. T.
5	4	10	i. *e.*
	7	37	ii. *e.*
	7	39	i. O.
	10	4	ii. E.
	10	8	ii. *o.*
	12	42	ii. O.
6	2	41	i. *t.*
	4	57	i. T.
	22	38	i. *e.*
7	2	8	i. O.
	4	34	ii. *t*
	7	9	ii. T.
	9	22	iii. *e.*
	11	44	iii. E.
	14	22	iii. *o.*
	17	4	iii. O.
	21	10	i. *t.*
	23	26	i. T.
8	17	7	i. *e.*
	20	37	i. O.
	20	55	ii. *e.*
	23	22	ii. E.
	23	29	ii. *o.*
9	2	3	ii. O.
	15	39	i. *t.*
	17	55	i. T.
10	11	35	i. *e.*
	15	6	i. O.
	17	53	ii. *t.*
	20	28	ii. T.
11	4	36	iii. *t.*

Sept. (con.).

d	h	m	
11	7	19	iii. T.
	10	8	i. *t.*
	12	24	i. T.
12	6	4	i. *e.*
	9	35	i. O.
	10	14	ii. *e.*
	12	41	ii. E.
	12	49	ii. *o.*
	15	23	ii. O.
13	4	37	i. *t.*
	6	53	i. T.
14	0	22	i. *e.*
	4	3	i. O.
	7	12	ii. *t.*
	9	47	ii. T.
	13	20	iii. *e.*
	15	44	iii. E.
	18	29	iii. *o.*
	21	12	iii. O.
	23	6	i. *t.*
15	1	22	i. T.
	19	0	i. *e.*
	22	32	i. O.
	23	31	ii. *e.*
16	1	59	ii. E.
	2	8	ii. *o.*
	4	43	ii. O.
	17	35	i. *t.*
	19	51	i. T.
17	13	29	i. *e.*
	17	1	i. O.
	20	30	ii. *t.*
	23	5	ii. T.
18	8	42	iii. *t.*
	11	25	iii. T.
	12	4	i. *t.*
	14	19	i. T.
19	7	57	i. *e.*
	11	29	i. O.
	12	50	ii. *e.*
	15	17	ii. E.
	15	28	ii. *o.*
	18	3	ii. O.
20	6	32	i. *t.*
	8	48	i. T.
21	2	25	i. *e.*
	5	58	i. O.
	9	48	ii. *t.*
	12	23	ii. T.
	17	18	iii. *e.*
	19	43	iii. E.
	22	32	iii. *o.*
22	1	1	i. *t.*
	1	16	iii. O.
	3	17	i. T.
	20	54	i. *e.*
23	0	26	i. O.
	2	8	ii. *e.*
	4	35	ii. E.
	4	46	ii. *o.*
	7	22	ii. O.
	19	29	i. *t.*
	21	45	i. T.
24	15	22	i. *e.*

Sept. (con.).

d	h	m	
24	18	55	i. O.
	23	5	ii. *t.*
25	1	41	ii. T.
	12	44	iii. *t.*
	13	58	i. *t.*
	15	29	iii. T.
	16	14	i. T.
26	9	50	i. *e.*
	13	23	i. O.
	15	26	ii. *e.*
	17	54	ii. E.
	18	4	ii. *o.*
	20	40	ii. O.
27	8	26	i. *t.*
	10	42	i. T.
28	4	19	i. *e.*
	7	52	i. O.
	12	22	ii. *t.*
	14	58	ii. T.
	21	17	iii. *e.*
	23	43	iii. E.
29	2	31	iii. *o.*
	2	55	i. *t.*
	5	11	i. T.
	5	16	iii. O.
	22	47	i. *e.*
30	2	20	i. O.
	4	44	ii. *e.*
	7	12	ii. E.
	7	22	ii. *o*
	9	58	ii. O.
	21	23	i. *t.*
	23	39	i. T.

October.

d	h	m	
1	17	15	i. *e.*
	20	48	i. O.
2	1	38	ii. *t.*
	4	14	ii. T.
	15	51	i. *t.*
	16	41	iii. *t.*
	18	7	i. T.
	19	27	iii. T.
3	11	44	i. *e.*
	15	16	i. O.
	18	2	ii. *e.*
	20	30	ii. E.
	20	39	ii. *o.*
	23	15	ii. O.
4	10	20	i. *t.*
	12	36	i. T.
5	6	12	i. *e.*
	9	44	i. O.
	14	54	ii. *t.*
	17	30	ii. T.
6	1	15	iii. *e.*
	3	43	iii. E.
	4	48	i. *t.*
	6	26	iii. *o.*
	7	4	i. T.
	9	12	iii. O.
7	0	40	i. *e.*
	4	12	i. O.

Oct. (con.).

d	h	m	
7	7	20	ii. *e.*
	9	48	ii. E.
	9	56	ii. *o.*
	12	32	ii. O.
	23	16	i. *t.*
8	1	32	i. T.
	19	9	i. *e.*
	22	40	i. O.
9	4	10	ii. *t.*
	6	45	ii. T.
	17	44	i. *t.*
	20	0	i. T.
	20	34	iii. *t.*
	23	21	iii. T.
10	13	37	i. *e.*
	17	8	i. O.
	20	38	ii. *e.*
	23	6	ii. E.
	23	12	ii. *o.*
11	1	48	ii. O.
	12	12	i. *t.*
	14	28	i. T.
12	8	5	i. *e.*
	11	36	i. O.
	17	24	ii. *t.*
	20	0	ii. T.
13	5	14	iii. *e.*
	6	40	i. *t.*
	7	42	iii. E.
	8	56	i. T.
	10	17	iii. *o.*
	13	4	iii. O.
14	2	34	i. *e.*
	6	4	i. O.
	9	55	ii. *e.*
	12	24	ii. E.
	12	27	ii. *o.*
	15	3	ii. O.
15	1	7	i. *t.*
	3	23	i. T.
	21	2	i. *e.*
16	0	31	i. O.
	6	39	ii. *t.*
	9	15	ii. T.
	19	35	i. *t.*
	21	51	i. T.
17	0	22	iii. *t.*
	3	9	iii. T.
	15	31	i. *e*
	18	59	i. O.
	23	14	ii. *e.*
18	4	18	ii. O.
	14	3	i. *t.*
	16	19	i. T.
19	9	59	i. *e.*
	13	27	i. O.
	19	52	ii. *t.*
	22	28	ii. T.
20	8	30	i. *t.*
	9	13	iii. *e.*
	10	46	i. T.
	11	43	iii. E.
	14	3	iii. *o.*
	16	51	iii. O.

Oct. (con.).

d	h	m	
21	4	27	i. *e*.
	7	54	i. O.
	12	31	ii. *e*.
	17	32	ii. O.
22	2	58	i. *t*.
	5	14	i. T.
	22	56	i. *e*.
23	2	21	i. O.
	9	6	ii. *t*.
	11	42	ii. T.
	21	25	i. *t*.
	23	41	i. T.
24	4	6	iii. *t*.
	6	53	iii. T.
	17	24	i. *e*.
	20	49	i. O.
25	1	49	ii. *e*.
	6	46	ii. O.
	15	53	i. *t*.
	18	9	i. T.
26	11	52	i. *e*.
	15	16	i. O.
	22	19	ii. *t*.
27	0	55	ii. T.
	10	20	i. *t*.
	12	36	i. T.
	13	12	iii. *e*.
	15	43	iii. E.
	17	45	iii. *o*.
	20	32	iii. O.
28	6	21	i. *e*.
	9	43	i. O.
	15	7	ii. *e*.
	19	58	ii. O.
29	4	47	i. *t*.
	7	3	i. T.
30	0	49	i. *e*.
	4	10	i. O.
	11	30	ii. *t*.
	14	7	ii. T.
	23	14	i. *t*.
31	1	30	i. T.
	7	45	iii. *t*.
	10	33	iii. T.
	19	18	i. *e*.
	22	37	i. O.
November.			
1	4	25	ii. *e*.
	9	11	ii. O.

Nov. (con.).

d	h	m	
1	17	41	i. *t*.
	19	57	i. T.
2	13	46	i. *e*.
	17	4	i. O.
3	0	42	ii. *t*.
	3	18	ii. T.
	12	8	i. *t*.
	14	24	i. T.
	17	10	iii. *e*.
	19	43	iii. E.
	21	21	iii. *o*.
4	0	9	iii. O.
	8	14	i. *e*.
	11	31	i. O.
	17	42	ii. *e*.
	22	22	ii. O.
5	6	35	i. *t*.
	8	51	i. T.
6	2	43	i. *e*.
	5	58	i. O.
	13	53	ii. *t*.
	16	29	ii. T.
7	1	2	i. *t*.
	3	18	i. T.
	11	19	iii. *t*.
	14	7	iii. T.
	21	11	i. *e*.
8	0	25	i. O.
	7	0	ii. *e*.
	11	33	ii. O.
	19	29	i. *t*.
	21	45	i. T.
9	15	40	i. *e*.
	18	52	i. O.
10	3	3	ii. *t*.
	5	40	ii. T.
	13	55	i. *t*.
	16	11	i. T.
	21	9	iii. *e*.
	23	43	iii. E.
11	0	53	iii. *o*.
	3	41	iii. O.
	10	8	i. *e*.
	13	19	i. O.
	20	18	ii. *e*.
12	0	44	ii. O.
	8	22	i. *t*.
	10	38	i. T.
13	4	37	i. *e*.
	7	45	i. O.

Nov. (con.).

d	h	m	
13	16	13	ii. *t*.
	18	50	ii. T.
14	2	49	i. *t*.
	5	5	i. T.
	14	50	iii. *t*.
	17	37	iii. T.
	23	5	i. *e*.
15	2	12	i. O.
	9	35	ii. *e*.
	13	54	ii. O.
	21	15	i. *t*.
	23	31	i. T.
16	17	34	i. *e*.
	20	38	i. O.
17	5	23	ii. *t*.
	7	59	ii. T.
	15	42	i. *t*.
	17	58	i. T.
18	1	7	iii. *e*.
	3	42	iii. E.
	4	20	iii. *o*.
	7	8	iii. O.
	12	2	i. *e*.
	15	5	i. O.
	22	53	ii. *e*.
19	3	3	ii. O.
	10	8	i. *t*.
	12	24	i. T.
20	6	30	i. *e*.
	9	31	i. O.
	18	32	ii. *t*.
	21	8	ii. T.
21	4	34	i. *t*.
	6	50	i. T.
	18	15	iii. *t*.
	21	3	iii. T.
22	0	59	i. *e*.
	3	57	i. O.
	12	11	ii. *e*.
	16	12	ii. O.
	23	1	i. *t*.
23	1	17	i. T.
	19	27	i. *e*.
	22	23	i. O.
24	7	40	ii. *t*.
	10	17	ii. T.
	17	27	i. *t*.
	19	43	i. T.
25	5	6	iii. *e*.
	7	43	iii. E.

Nov. (con.).

d	h	m	
25	7	43	iii. *o*.
	10	31	iii. O.
	13	56	i. *e*.
	16	50	i. O.
26	1	28	ii. *e*.
	5	20	ii. O.
	11	53	i. *t*.
	14	9	i. T.
27	8	24	i. *e*.
	11	16	i. O.
	20	49	ii. *t*.
	23	25	ii. T.
28	6	19	i. *t*.
	8	35	i. T.
	21	37	iii. *t*.
29	0	24	iii. T.
	2	53	i. *e*.
	5	42	i. O.
	14	46	ii. *e*.
	18	28	ii. O.
30	0	45	i. *t*.
	3	1	i. T.
	21	22	i. *e*.
December.			
1	0	8	i. O.
	9	57	ii. *t*.
	12	33	ii. T.
	19	11	i. *t*.
	21	27	i. T.
2	9	5	iii. *e*.
	13	51	iii. O.
	15	50	i. *e*.
	18	34	i. O.
3	4	3	ii. *e*.
	7	36	ii. O.
	13	37	i. *t*.
	15	53	i. T.
4	10	19	i. *e*.
	13	0	i. O.
	23	5	ii. *t*.
5	1	41	ii. T.
	8	3	i. *t*.
	10	19	i. T.
6	0	55	iii. *t*.
	3	42	iii. T.
	4	47	i. *e*.
	7	26	i. O.
	17	21	ii. *e*.
	20	43	ii. O.

Dec. (con.).

d	h	m	
7	2	29	i. *t*.
	4	45	i. T.
	23	16	i. *e*.
8	1	52	i. O.
	12	12	ii. *t*.
	14	48	ii. T.
	20	55	i. *t*.
	23	11	i. T.
9	13	5	iii. *e*.
	17	9	iii. O.
	17	44	i. *e*.
	20	18	i. O.
10	6	38	ii. *e*.
	9	50	ii. O.
	15	21	i. *t*.
	17	37	i. T.
11	12	13	i. *e*.
	14	44	i. O.
12	1	19	ii. *t*.
	3	56	ii. T.
	9	47	i. *t*.
	12	3	i. T.
13	4	11	iii. *t*.
	6	42	i. *e*.
	6	59	iii. T.
	9	10	i. O.
	19	56	ii. *e*.
	22	57	ii. O.
14	4	13	i. *t*.
	6	29	i. T.
15	1	10	i. *e*.
	3	36	i. O.
	14	26	ii. *t*.
	17	3	ii. T.
	22	38	i. *t*.
16	0	55	i. T.
	17	5	iii. *e*.
	19	39	i. *e*.
	20	25	iii. O.
	22	2	i. O.
17	9	13	ii. *e*.
	12	3	ii. O.
	17	4	i. *t*.
	19	20	i. T.
18	14	7	i. *e*.
	16	28	i. O.
19	3	34	ii. *t*.
	6	10	ii. T.
	11	30	i. *t*.
	13	46	i. T.

Dec. (con.)

d	h	m	
20	7	26	iii.
	8	36	i. *e*.
	10	14	iii.
	10	53	i. O
	22	31	ii.
21	1	10	ii.
	5	56	i. *t*.
	8	12	i. T
22	3	3	i. *o*.
	5	19	i. O
	16	41	ii. *t*
	19	17	ii. T
23	0	22	i. *t*.
	2	38	i. T.
	20	52	iii.
	21	29	i. *o*.
	23	45	i. E.
	23	46	iii.
24	11	40	ii. *o*.
	14	20	ii. E
	18	48	i. *t*.
	21	4	i. T.
25	15	15	i. *o*.
	18	14	i. E.
26	5	49	ii. *t*.
	8	25	ii. T.
	13	13	i. *t*.
	15	30	i. T.
27	10	21	i. *o*.
	10	41	iii.
	12	43	i. E.
	13	29	iii.
28	0	47	ii. *o*.
	3	38	ii. E
	7	39	i. *t*.
	9	55	i. T.
29	4	47	i. *o*.
	7	11	i. E.
	18	56	ii. *t*.
	21	32	ii. T.
30	2	5	i. *t*.
	4	21	i. T.
	23	13	i. *o*.
31	0	7	iii.
	1	40	i. E.
	3	46	iii.
	13	53	ii. *o*.
	16	56	ii. E
	20	31	i. *t*.
	22	47	i. T.

Satellite I. *reappears* at eclipse on the *f* side from January to May. It *disappears* on the *p* side fro July to December.

Satellite II. both *disappears* and *reappears* at eclipse from January 3 to March 29, and also fr September 1 to October 28. From April 2 to May 7 it *reappears* only on the *f* side. In July a August, and again in November and December, it *disappears* only on the *p* side.

Satellite III. *disappears* and *reappears* on the *f* side from Jan. to May, on the *p* side from July to D

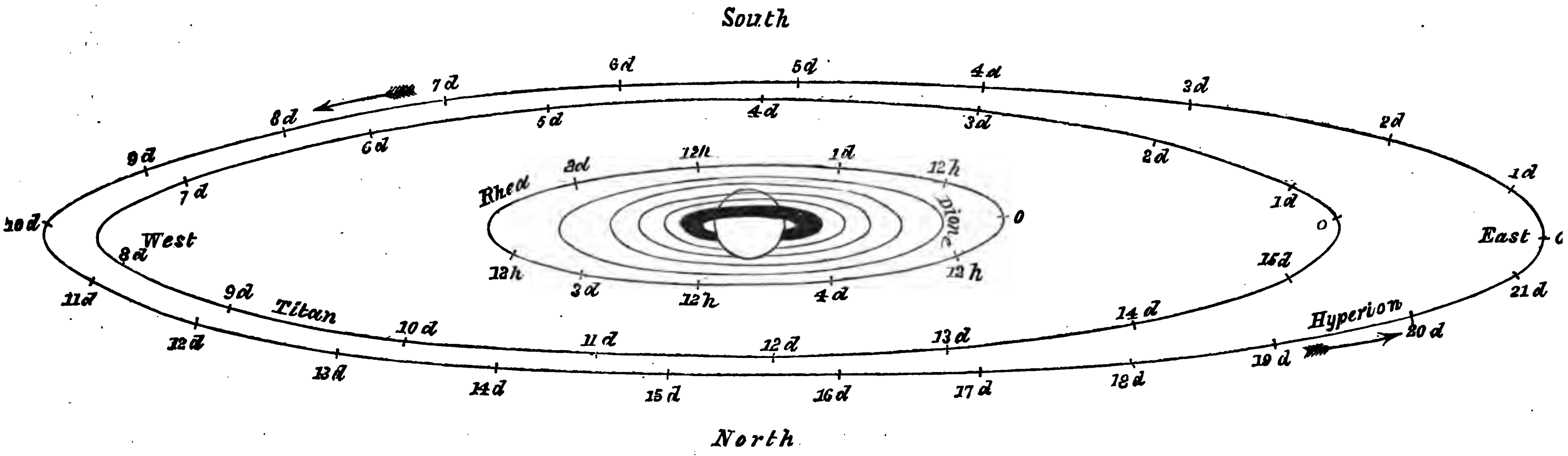
Satellite IV. is not eclipsed in 1894.

JUPITER'S IVTH SATELLITE.

Greenwich Mean Times of Superior Geocentric Conjunction.

	h m		h m		h m		h m
Jan. 12 ...	22 46·7			Aug. 2 ...	21 29·8	Oct. 25 ...	18 29·8
29 ...	15 45·3	Apr. 6 ...	20 20·1	19 ...	17 29·6	Nov. 11 ...	10 22·3
Feb. 15 ...	9 44·6	23 ...	16 51·8	Sept. 5 ...	12 56·6	28 ...	1 17·6
Mar. 4 ...	4 37·2			22 ...	7 42·0	Dec. 14 ...	15 32·2
21 ...	0 11·7	July 17 ...	1 5·3	Oct. 9 ...	1 35·3	31 ...	5 33·5

APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, as seen in an Inverting Telescope.



The arrows in the diagram show the direction of the motion of the Satellites. The figures indicate the interval from the time of last East Elongation.

SATELLITES OF SATURN.

East Elongations.

Mimas.

January.		February.		March.		April.		May.		June.		July.		Decemb	
d	h	d	h	d	h	d	h	d	h	d	h	d	h	d	h
1	12·5	1	14·7	1	21·2	1	0·9	1	4·5	1	6·9	1	10·8	19	1·
2	11·1	2	13·4	2	19·8	1	23·5	2	3·1	2	5·6	2	9·4	20	0·
3	9·7	3	12·0	3	18·4	2	22·1	3	1·7	3	4·2	3	8·0	20	23·
4	8·3	4	10·6	4	17·0	3	20·7	4	0·3	4	2·8	4	6·7	21	21·
5	6·9	5	9·2	5	15·6	4	19·3	4	22·9	5	1·4	5	5·3	22	20·
6	5·5	6	7·8	6	14·3	5	17·9	5	21·5	6	0·0	6	4·0	23	18·
7	4·1	7	6·5	7	12·9	6	16·5	6	20·2	6	22·6	7	2·6	24	17·5
8	2·7	8	5·1	8	11·5	7	15·1	7	18·9	7	21·2	8	1·2	25	16·1
9	1·3	9	3·7	9	10·1	8	13·7	8	17·5	8	19·8	8	23·8	26	14·7
10	0·0	10	2·3	10	8·7	9	12·3	9	16·1	9	18·5	9	22·4	27	13·3
10	22·6	11	0·9	11	7·3	10	11·0	10	14·8	10	17·1	10	21·0	28	12·0
11	21·2	11	23·5	12	6·0	11	9·6	11	13·4	11	15·8	11	19·6	29	10·6
12	19·8	12	22·1	13	4·6	12	8·2	12	12·0	12	14·4	12	18·2	30	9·2
13	18·4	13	20·8	14	3·2	13	6·8	13	10·6	13	13·0	13	16·8	31	7·8
14	17·0	14	19·4	15	1·8	14	5·4	14	9·2	14	11·6	14	15·4		
15	15·6	15	18·0	16	0·4	15	4·0	15	7·8	15	10·2	15	14·0		
16	14·2	16	16·6	16	23·0	16	2·7	16	6·4	16	8·9	16	12·6		
17	12·8	17	15·2	17	21·6	17	1·3	17	5·1	17	7·5	17	11·2		
18	11·5	18	13·8	18	20·3	18	0·0	18	3·7	18	6·1	18	9·8		
19	10·1	19	12·5	19	18·9	18	22·6	19	2·3	19	4·7	19	8·4		
20	8·8	20	11·1	20	17·5	19	21·2	20	0·9	20	3·3	20	7·1		
21	7·4	21	9·7	21	16·1	20	19·8	20	23·5	21	2·0	21	5·7		
22	6·0	22	8·3	22	14·7	21	18·4	21	22·2	22	0·6	22	4·3		
23	4·6	23	6·9	23	13·3	22	17·0	22	20·8	22	23·2	23	3·0		
24	3·2	24	5·5	24	12·0	23	15·6	23	19·4	23	21·8	24	1·6		
25	1·9	25	4·1	25	10·6	24	14·2	24	18·0	24	20·4				
26	0·5	26	2·7	26	9·2	25	12·8	25	16·6	25	19·0				
26	23·1	27	1·4	27	7·8	26	11·4	26	15·3	26	17·6				
27	21·7	28	0·0	28	6·4	27	10·0	27	13·9	27	16·3				
28	20·3	28	22·6	29	5·0	28	8·7	28	12·5	28	14·9				
29	18·9			30	3·7	29	7·3	29	11·1	29	13·5				
30	17·5			31	2·3	30	5·9	30	9·7	30	12·2				
31	16·1							31	8·3						

Enceladus.

January.		February.		March.		April.		May.		June.		July.		December	
d	h	d	h	d	h	d	h	d	h	d	h	d	h	d	h
1	20·2	2	8·4	1	18·0	2	6·3	1	0·7	1	13·0	1	16·3	18	15·7
3	5·1	3	17·3	3	2·9	3	15·1	2	9·6	2	21·9	3	1·2	20	0·6
4	13·9	5	2·2	4	11·8	5	0·0	3	18·5	4	6·7	4	10·1	21	9·5
5	22·8	6	11·1	5	20·7	6	8·9	5	3·4	5	15·6	5	19·0	22	18·4
7	7·7	7	19·9	7	5·5	7	17·8	6	12·3	7	0·5	7	3·9	24	3·3
8	16·6	9	4·8	8	14·4	9	2·7	7	21·1	8	9·4	8	12·7	25	12·2
10	1·5	10	13·7	9	23·3	10	11·5	9	6·0	9	18·2	9	21·6	26	21·
11	10·3	11	22·5	11	8·2	11	20·4	10	14·9	11	3·1	11	6·5	28	6·0
12	19·2	13	7·5	12	17·1	13	5·3	11	23·8	12	12·0			29	14·9
14	4·1	14	16·3	14	1·9	14	14·2	13	8·7	13	20·9			30	23·
15	13·0	16	1·2	15	10·8	15	23·1	14	17·5	15	5·8				
16	21·9	17	10·1	16	19·7	17	7·9	16	2·4	16	14·7				
18	6·7	18	19·0	18	4·6	18	16·8	17	11·3	17	23·5				
19	15·6	20	3·9	19	13·5	20	1·7	18	20·2	19	8·4				
21	0·5	21	12·7	20	22·3	21	10·6	20	5·1	20	17·3				
22	9·4	22	21·6	22	7·2	22	19·5	21	13·9	22	2·2				
23	18·3	24	6·5	23	16·1	24	4·3	22	22·8	23	11·1				
25	3·1	25	15·4	25	1·0	25	13·2	24	7·7	24	19·9				
26	12·0	27	0·3	26	9·9	26	22·1	25	16·6	26	4·8				
27	20·9	28	9·1	27	18·7	28	7·0	27	1·5	27	13·7				
29	5·8			29	3·6	29	15·9	28	10·3	28	22·6				
30	14·7			30	12·5			29	19·2	30	7·5				
31	23·5			31	21·4			31	4·1						

East Elongations.

Tethys.

January.	February.	March.	April.	May.	June.	July.	December.
d h	d h	d h	d h	d h	d h	d h	d h
2 17·7	1 22·4	2 5·9	1 10·7	1 15·4	2 17·5	1 0·9	19 22·0
4 15·0	3 19·7	4 3·2	3 8·0	3 12·7	4 14·8	2 22·2	21 19·3
6 12·3	5 17·0	6 0·5	5 5·3	5 10·0	6 12·0	4 19·5	23 16·7
8 9·6	7 14·3	7 21·8	7 2·5	7 7·3	8 9·3	6 16·8	25 14·0
10 6·9	9 11·6	9 19·1	8 23·8	9 4·6	10 6·6	8 14·1	27 11·3
12 4·2	11 8·9	11 16·4	10 21·1	11 1·9	12 3·9	10 11·4	29 8·6
14 1·5	13 6·2	13 13·7	12 18·4	12 23·2	14 1·2		31 6·0
15 22·8	15 3·5	15 11·0	14 15·7	14 20·5	15 22·5		
17 20·1	17 0·8	17 8·3	16 13·0	16 17·8	17 19·8		
19 17·4	18 22·1	19 5·6	18 10·3	18 15·1	19 17·1		
21 14·7	20 19·4	21 2·9	20 7·6	20 12·4	21 14·4		
23 12·0	22 16·7	23 0·2	22 4·9	22 9·7	23 11·7		
25 9·3	24 14·0	24 21·5	24 2·2	24 7·0	25 9·0		
27 6·6	26 11·3	26 18·8	25 23·5	26 4·3	27 6·3		
29 3·9	28 8·6	28 16·1	27 20·8	28 1·6	29 3·6		
31 1·2		30 13·4	29 18·1	29 22·9			
				31 20·2			

Dione.

January.	February.	March.	April.	May.	June.	July.	December.
d h	d h	d h	d h	d h	d h	d h	d h
2 6·7	1 9·1	3 11·5	2 13·9	2 16·3	1 18·7	1 21·2	21 10·1
5 0·3	4 2·8	6 5·2	5 7·6	5 10·0	4 12·4	4 14·8	24 3·8
7 18·0	6 20·4	8 22·8	8 1·3	8 3·7	7 6·1		26 21·6
10 11·7	9 14·1	11 16·5	10 18·9	10 21·4	9 23·8		29 15·3
13 5·4	12 7·8	14 10·2	13 12·6	13 15·0	12 17·4		
15 23·0	15 1·4	17 3·9	16 6·3	16 8·7	15 11·1		
18 16·7	17 19·1	19 21·5	19 0·0	19 2·4	18 4·8		
21 10·4	20 12·8	22 15·2	21 17·6	21 20·0	20 22·5		
24 4·1	23 6·5	25 8·9	24 11·3	24 13·7	23 16·1		
26 21·7	26 0·1	28 2·6	27 5·0	27 7·4	26 9·8		
29 15·4	28 17·8	30 20·2	29 22·7	30 1·1	29 3·5		

Rhea.

January.	February.	March.	April.	May.	June.	July.	December.
d h	d h	d h	d h	d h	d h	d h	d h
2 11·0	3 1·7	2 3·9	2 18·6	4 9·3	4 23·9	2 2·2	20 22·7
6 23·4	7 14·0	6 16·3	7 7·0	8 21·6	9 12·3		25 11·3
11 11·8	12 2·4	11 4·7	11 19·4	13 10·0	14 0·7		29 23·8
16 0·1	16 14·8	15 17·1	16 7·7	17 22·4	18 13·0		
20 12·5	21 3·2	20 5·5	20 20·1	22 10·8	23 1·4		
25 0·9	25 15·6	24 17·8	25 8·5	26 23·2	27 13·8		
29 13·3		29 6·2	29 20·9	31 11·5			

Titan.

January.	February.	March.	April.	May.	June.		December.
d h	d h	d h	d h	d h	d h		d h
7 9·5	8 6·9	12 3·9	12 23·0	14 17·8	15 13·4	......	24 15·9
23 8·3	24 5·2	28 1·9	28 20·5	30 15·3		......	

East Elongations.

HYPERION.

January.	February.	March.	April.	May.	June.	July.	December.
d h	d h	d h	d h	d h	d h	d h	d h
5 21.9	17 10.7	10 16.7	22 2.3	13 7.0	3 11.8	16 1.0	13 7.1
27 4.1		31 22.0			24 17.6		

IAPETUS.

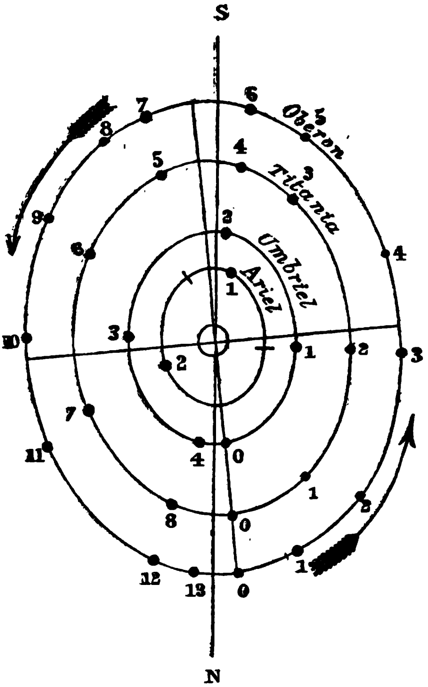
d h d h d h d h
Inf. Conjunction ... Feb. 7 16.5, Apr. 27 3.2, July 14 11.3, Dec. 24 0.1.
W. Elongation ...... Feb. 27 19.0, May 16 22.3.
Sup. Conjunction ... Mar. 19 15.9, June 5 21.7.
E. Elongation ...... Jan. 20 10.3, Apr. 9 3.0, June 26 10.0, Dec. 5 18.3.

Apparent Elements of Saturn's Rings.

Greenwich Mean Noon.	Position-angle of Minor Axis.	Outer Ring. Maj. Axis.	Outer Ring. Min. Axis.	Latitude above Plane of Ring. Earth.	Latitude above Plane of Ring. Sun.
	° ′	″	″	° ′	° ′
Jan. 0	358 19.2	38.03	9.15	13 55.1 N.	11 34.9 N.
20	358 24.9	39.35	9.62	14 8.9 N.	11 50.9 N.
Feb. 9	358 25.9	40.72	9.92	14 6.6 N.	12 6.8 N.
Mar. 1	358 22.3	41.93	10.01	13 48.6 N.	12 22.7 N.
21	358 14.9	42.79	9.84	13 18.3 N.	12 38.5 N.
April 10	358 5.2	43.13	9.48	12 41.8 N.	12 54.0 N.
30	357 55.4	42.87	8.99	12 6.2 N.	13 9.7 N.
May 20	357 47.5	42.07	8.50	11 39.2 N.	13 25.2 N.
June 9	357 42.8	40.90	8.11	11 26.0 N.	13 40.5 N.
29	357 42.2	39.57	7.88	11 29.2 N.	13 55.8 N.
July 19	357 45.7	38.23	7.82	11 48.7 N.	14 11.0 N.
Aug. 8	357 53.3	37.04	7.93	12 22.4 N.	14 26.0 N.
28	358 4.0	35.98	8.16	13 6.9 N.	14 40.9 N.
Sept. 17	358 17.5	35.37	8.54	13 59.0 N.	14 55.7 N.
Oct. 7	358 33.0	34.98	9.00	14 54.5 N.	15 10.4 N.
27	358 49.6	34.91	9.52	15 49.5 N.	15 24.9 N.
Nov. 16	359 6.3	35.18	10.10	16 40.8 N.	15 39.4 N.
Dec. 6	359 21.9	35.81	10.72	17 25.0 N.	15 53.8 N.
26	359 35.3	36.66	11.32	17 59.4 N.	16 8.0 N.
31	359 38.0	36.93	11.47	18 6.1 N.	16 11.5 N.

TABLE OF BESSEL'S MEAN REFRACTIONS.

Z. D.	Mean Refraction.	Z. D.	Mean Refraction.	Z. D.	Mean Refraction.	Z. D.	Mean Refraction.
°	′ ″	°	′ ″	°	′ ″	°	′ ″
0	0.0	56	1 25.4	68	2 21.9	78	4 25.0
10	10.2	58	1 32.1	69	2 29.3	79	4 48.5
20	21.6	60	1 39.7	70	2 37.3	80	5 16.2
30	33.3	61	1 43.8	71	2 46.1	81	5 49.3
35	40.4	62	1 48.2	72	2 55.8	82	6 29.6
40	48.4	63	1 52.8	73	3 6.6	83	7 19.7
45	57.7	64	1 57.8	74	3 18.6	84	8 23.3
50	1 8.7	65	2 3.2	75	3 32.1	85	9 46.5
52	1 13.8	66	2 8.9	76	3 47.4		
54	1 19.3	67	2 15.2	77	4 4.9		



Apparent Orbits of the Satellites of Uranus, as seen in an inverting telescope.

The small circle in the above diagram represents the planet, the arrows show the direction of motion, and the figures indicate the interval from the time of the last North Elongation.

North Elongations.

Ariel.

January.		February.		March.		April.		May.		June.		July.	
d	h	d	h	d	h	d	h	d	h	d	h	d	h
24	22·5	1	11·9	1	5·2	2	23·5	3	5·2	2	11·0	2	16·7
27	11·0	4	0·4	3	17·7	5	12·0	5	17·7	4	23·5	5	5·2
29	23·5	6	12·9	6	6·2	8	0·4	8	6·2	7	12·0	7	17·7
		9	1·4	8	18·6	10	12·9	10	18·7	10	0·4	10	6·2
		11	13·9	11	7·1	13	1·4	13	7·2	12	12·9	12	18·7
		14	2·3	13	19·6	15	13·8	15	19·6	15	1·4	15	7·1
		16	14·8	16	8·1	18	2·3	18	8·1	17	13·9	17	19·6
		19	3·3	18	20·6	20	14·8	20	20·6	20	2·4	20	8·1
		21	15·8	21	9·1	23	3·3	23	9·0	22	14·9	22	20·6
		24	4·3	23	21·5	25	15·8	25	21·5	25	3·3	25	9·1
		26	16·8	26	10·0	28	4·3	28	10·0	27	15·8		
				28	22·5	30	16·7	30	22·5	30	4·2		
				31	11·0								

UMBRIEL.

January.		February.		March.		April.		May.		June.		July.		August.	
d	h	d	h	d	h	d	h	d	h	d	h	d	h	d	h
24	3·4	1	10·3	2	10·5	4	14·3	3	14·6	1	14·9	4	18·8	2	19·2
28	6·9	5	13·8	6	14·0	8	17·8	7	18·1	5	18·4	8	22·3	6	22·7
		9	17·3	10	17·5	12	21·3	11	21·5	9	21·9	13	1·8	11	2·1
		13	20·8	14	21·0	17	0·7	16	1·0	14	1·3	17	5·3		
		18	0·2	19	0·5	21	4·2	20	4·5	18	4·8	21	8·8		
		22	3·7	23	3·9	25	7·6	24	8·0	22	8·3	25	12·2		
		26	7·1	27	7·4	29	11·1	28	11·4	26	11·8	29	15·7		
				31	10·8					30	15·2				

TITANIA.

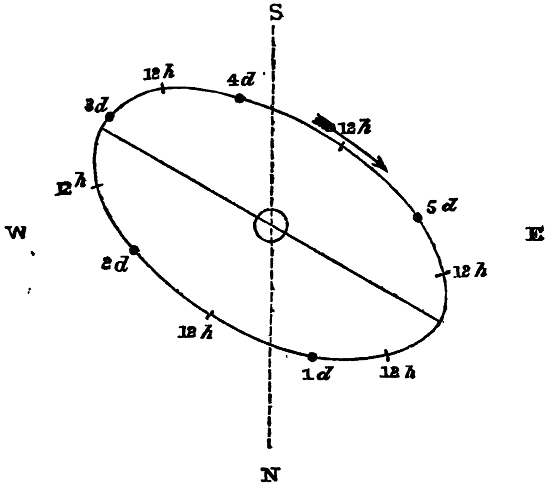
22	10·6	8	20·5	6	23·5	2	2·4	6	22·3	2	1·3	6	21·2	2	0·1
31	3·6	17	13·5	15	16·5	10	19·4	15	15·3	10	18·2	15	14·2	10	17·1
		26	6·5	24	9·4	19	12·4	24	8·3	19	11·2	24	7·1	19	10·1
						28	5·4			28	4·2				

OBERON.

26	3·6	8	14·9	7	13·3	3	11·7	13	21·4	9	19·9	6	18·4	……	
		22	2·1	21	0·5	16	22·9	27	8·7	23	7·2			……	
						30	10·2								

Position-angle and distance of the apse of Oberon:—February 2, $2^\circ{\cdot}5$, $43''{\cdot}4$; May 3, $3^\circ{\cdot}8$, $45''{\cdot}8$; July 16, $5^\circ{\cdot}0$, $44''{\cdot}1$.

SATELLITE OF NEPTUNE.



Apparent Orbit of the Satellite of Neptune, as seen in an inverting telescope.

The small circle in the above diagram represents the planet, the arrows show the direction of motion, and the figures indicate the interval from the time of last North-east Elongation.

North-east Elongations.

January.		February.		March.		August.		September.		October.		November.		December.	
d	h	d	h	d	h	d	h	d	h	d	h	d	h	d	h
5	1·1	3	10·6	4	20·2	22	3·7	2	21·9	2	7·4	6	14·0	5	23·5
10	22·1	9	7·7	10	17·3	28	0·8	8	19·0	8	4·5	12	11·1	11	20·6
16	19·3	15	4·8					14	16·1	14	1·6	18	8·2	17	17·7
22	16·4	21	1·9					20	13·2	19	22·7	24	5·3	23	14·8
28	13·5	26	23·0					26	10·3	25	19·8	30	2·4	29	11·9
										31	16·9				

Position-angle and distance of the apse:—February 6, $245^\circ{\cdot}9$, $16''{\cdot}6$; October 8, $250^\circ{\cdot}9$, $16''{\cdot}7$; December 6, $249^\circ{\cdot}5$, $16''{\cdot}9$.

EPHEMERIS FOR PHYSICAL OBSERVATIONS OF THE SUN.

Greenwich Mean Noon.				Greenwich Mean Noon.			
1894.	P.	D.	L.	1894.	P.	D.	L.
	° ′	° ′	° ′		° ′	° ′	° ′
Jan. 1	+ 1 41	−3 18	283 38	July 5	− 0 36	+3 32	1 46
6	− 0 46	3 51	217 47	10	+ 1 42	4 4	295 35
11	3 11	4 23	151 56	15	3 56	4 33	229 26
16	5 33	4 53	86 5	20	6 9	5 0	163 17
21	7 52	5 20	20 16	25	8 18	5 25	97 8
26	10 4	5 45	314 27	30	10 22	5 48	31 0
31	12 12	6 7	248 35	Aug. 4	12 21	6 9	324 53
Feb. 5	14 12	6 26	182 45	9	14 14	6 27	258 46
10	16 4	6 43	116 55	14	16 1	6 42	192 40
15	17 49	6 56	51 5	19	17 41	6 55	126 36
20	19 25	7 12	345 15	24	19 14	7 4	60 31
25	20 52	7 12	279 22	29	20 38	7 11	354 27
Mar. 2	22 9	7 15	213 31	Sept. 3	21 55	7 14	288 25
7	23 16	7 14	147 38	8	23 2	7 15	222 25
12	24 15	7 11	81 46	13	24 2	7 12	156 24
17	25 3	7 4	15 52	18	24 51	7 6	90 22
22	25 41	6 54	309 56	23	25 31	6 58	24 22
27	26 8	6 41	243 59	28	26 1	6 45	318 23
Apr. 1	26 24	6 25	178 1	Oct. 3	26 21	6 30	252 26
6	26 30	6 6	112 3	8	26 30	6 12	186 28
11	26 25	5 44	46 3	13	26 27	5 51	120 30
16	26 8	5 20	340 1	18	26 14	5 27	54 32
21	25 41	4 54	273 59	23	25 49	5 1	348 36
26	25 2	4 26	207 54	28	25 12	4 33	282 39
May 1	24 13	3 56	141 51	Nov. 2	24 24	4 2	216 45
6	23 12	3 24	75 45	7	23 23	3 30	150 48
11	22 1	2 51	9 38	12	22 11	2 56	84 52
16	20 40	2 17	303 30	17	20 47	2 20	18 58
21	19 9	1 42	237 21	22	19 12	1 43	313 5
26	17 29	1 7	171 12	27	17 5	1 56	247 11
31	15 41	−0 31	105 2	Dec. 2	15 33	+0 28	181 15
June 5	13 45	+0 5	38 52	7	13 29	−0 11	115 21
10	11 43	0 41	332 41	12	11 18	0 49	49 31
15	9 36	1 18	266 29	17	9 1	1 27	343 36
20	7 24	1 53	200 18	22	6 39	2 5	277 45
25	5 9	2 27	134 7	27	4 14	2 41	211 52
30	− 2 53	+3 1	67 56	32	+ 1 48	−3 16	146 2

The position-angle of the Sun's axis, P, is the position-angle of the N. end of the axis from the N. point of the Sun, read in the direction N., E., S., W. In computing D (the heliographic latitude of the centre of the Sun's disk), the inclination of the Sun's axis to the ecliptic has been assumed to be 82° 45′, and the longitude of the ascending node to be 74° 20′. In computing L (the heliographic longitude of the centre of the disk), the Sun's period of rotation has been assumed to be 25·38 days, and the meridian which passed through the ascending node at the epoch 1854·0 has been taken as the zero meridian.

MEAN PLACES OF VARIABLE STARS FOR 1890.

No.	Star.	R.A.	Dec.	No.	Star.	R.A.	Dec.
		h m s	° ′			h m s	° ′
1.	T Ceti	0 16 12	−20 40·1	53.	U Canis Min.	7 35 22	+ 8 38·2
2.	T Cassiopeiæ	0 17 17	+55 11·0	54.	S Geminorum	7 36 26	+23 42·6
3.	R Andromedæ	0 18 13	+37 58·1	55.	T Geminorum	7 42 41	+24 0·5
4.	S Ceti	0 18 28	− 9 56·3	56.	U Geminorum	7 48 34	+22 17·5
5.	U Cassiopeiæ	0 40 13	+47 39·3	57.	U Puppis	7 55 42	−12 33·7
6.	U Cephei	0 52 32	+81 16·9	58.	R Cancri	8 10 30	+12 3·9
7.	S Cassiopeiæ	1 11 34	+72 1·9	59.	V Cancri	8 15 26	+17 38·0
8.	S Piscium	1 11 49	+ 8 21·1	60.	U Cancri	8 29 28	+19 16·5
9.	U Piscium	1 17 9	+12 17·4	61.	S Cancri	8 37 39	+19 25·8
10.	R Sculptoris	1 21 55	−33 6·8	62.	S Hydræ	8 47 50	+ 3 29·0
11.	R Piscium	1 24 58	+ 2 18·8	63.	T Hydræ	8 50 19	− 8 43·3
12.	S Arietis	1 58 43	+11 59·9	64.	T Cancri	8 50 23	+20 16·1
13.	R Arietis	2 9 51	+24 32·7	65.	S Antliæ	9 27 30	−28 8·6
14.	*o* Ceti	2 13 47	− 3 28·6	66.	R Carini	9 29 28	−62 18·1
15.	S Persei	2 14 59	+58 5·0	67.	R Leo. Min.	9 38 59	+35 1·2
16.	R Ceti	2 20 24	− 0 40·5	68.	R Leonis	9 41 39	+11 56·4
17.	U Ceti	2 28 26	−13 37·8	69.	*l* Carini	9 42 14	−62 0·1
18.	R Trianguli	2 30 22	+33 47·1	70.	V Leonis	9 53 57	+21 47·2
19.	T Arietis	2 42 11	+17 3·1	71.	S Carini	10 55 53	−61 0·8
20.	ρ Persei	2 58 8	+38 24·9	72.	U Hydræ	10 32 7	−12 48·8
21.	Algol	3 1 1	+40 32·0	73.	R Ursæ Maj.	10 36 50	+69 21·2
22.	R Persei	3 23 3	+35 17·7	74.	V Hydræ	10 46 16	−20 39·9
23.	λ Tauri	3 54 35	+12 10·8	75.	W Leonis	10 47 49	+14 18·1
24.	W Tauri	4 21 45	+15 51·3	76.	R Crateris	10 55 9	−17 44·0
25.	R Tauri	4 22 16	+ 9 55·0	77.	S Leonis	11 5 9	+ 6 3·5
26.	S Tauri	4 23 10	+ 9 42·1	78.	R Comæ	11 58 37	+19 23·9
27.	T Camelopardi	4 29 30	+65 58·0	79.	T Virginis	12 8 58	− 5 25·4
28.	R Reticuli	4 32 24	−63 15·4	80.	R Corvi	12 13 56	−18 38·6
29.	V Tauri	4 45 39	+17 21·1	81.	Y Virginis	12 28 12	− 3 48·9
30.	R Orionis	4 53 2	+ 7 57·8	82.	T Ursæ Maj.	12 31 23	+60 5·6
31.	R Leporis	4 54 35	−14 58·3	83.	R Virginis	12 32 55	+ 7 35·6
32.	R Aurigæ	5 8 24	+53 27·7	84.	S Ursæ Maj.	12 39 7	+61 41·8
33.	S Aurigæ	5 19 51	+34 3·1	85.	U Virginis	12 45 31	+ 6 9·2
34.	S Orionis	5 23 35	− 4 46·9	86.	W Virginis	13 20 21	− 2 48·4
35.	S Camelopardi	5 29 11	+68 44·2	87.	V Virginis	13 22 7	− 2 36·1
36.	U Aurigæ	5 35 3	+31 58·2	88.	R Hydræ	13 23 42	−22 42·7
37.	U Orionis	5 49 17	+20 9·3	89.	S Virginis	13 27 15	− 6 37·7
38.	η Geminorum	6 8 14	+22 32·3	90.	W Hydræ	13 42 50	−27 49·1
39.	V Aurigæ	6 15 35	+47 42·5	91.	R Canum Ven.	13 44 15	+40 5·2
40.	V Monocerotis	6 17 11	− 2 8·5	92.	R² Virginis	13 59 3	− 8 40·2
41.	T Monocerotis	6 19 17	+ 7 8·8	93.	Z Virginis	14 4 25	−12 47·0
42.	S Monocerotis	6 34 55	+ 9 59·4	94.	R Centauri	14 8 43	−59 24·1
43.	R Lyncis	6 52 13	+55 29·1	95.	X Boötis	14 18 59	+16 49·3
44.	ζ Geminorum	6 57 35	+20 43·8	96.	S Boötis	14 19 12	+54 18·7
45.	R Geminorum	7 0 43	+22 52·4	97.	V Boötis	14 25 20	+39 21·0
46.	R Canis Min.	7 2 39	+10 11·8	98.	R Camelopardi	14 25 55	+84 19·9
47.	L² Puppis	7 10 12	−44 27·8	99.	R Boötis	14 32 20	+27 12·8
48.	R Canis Maj.	7 14 30	−16 11·2	100.	V Libræ	14 34 15	−17 12·6
49.	V Geminorum	7 16 59	+13 18·1	101.	U Boötis	14 49 15	+18 8·6
50.	U Monocerotis	7 25 32	− 9 32·8	102.	δ Libræ	14 55 6	− 8 4·9
51.	S Canis Min.	7 26 45	+ 8 33·2	103.	T Libræ	15 4 28	−19 36·0
52.	T Canis Min.	7 27 53	+11 58·8	104.	Y Libræ	15 5 52	− 5 35·6

Mean Places of Variable Stars for 1890 (continued).

No.	Star.	R.A.	Dec.	No.	Star.	R.A.	Dec.
		h m s	° ′			h m s	°
105.	U Coronæ	15 13 43	+32 2·9	149.	S Sagittarii......	19 12 59	−19 13·5
106.	S Libræ	15 15 4	−19 59·5	150.	U Aquilæ	19 23 26	− 7 16·2
107.	S Serpentis......	15 16 31	+14 42·5	151.	R Cygni	19 33 52	+49 57·2
108.	S Coronæ	15 16 55	+31 45·7	152.	S Vulpeculæ ...	19 43 53	+27 0·7
109.	X Libræ	15 29 52	−20 47·9	153.	χ Cygni	19 46 20	+32 38·1
110.	W Libræ.........	15 31 42	−15 48·8	154.	η Aquilæ.........	19 46 52	+ 0 43·4
111.	U Libræ	15 35 39	−20 49·5	155.	S Sagittæ	19 51 1	+16 20·5
112.	Z Libræ	15 40 7	−20 47·2	156.	Z Cygni	19 58 22	+49 44·1
113.	V Coronæ	15 45 37	+39 54·1	157.	S Cygni	20 3 11	+57 40·1
114.	R Serpentis......	15 45 38	+15 28·1	158.	R Capricorni ...	20 5 8	−14 35·7
115.	R Libræ	15 47 22	−15 54·5	159.	S Aquilæ.........	20 6 34	+15 17·7
116.	R² Libræ.........	15 50 5	−17 58·8	160.	W Capricorni...	20 8 0	−22 18·6
117.	Z Scorpii.........	15 59 36	−21 25·9	161.	R Sagittæ	20 9 3	+16 23·6
118.	R Herculis	16 1 17	+18 40·1	162.	R Delphini......	20 9 37	+ 8 45·4
119.	X Scorpii	16 2 5	−21 13·8	163.	U Cygni	20 16 12	+47 32·8
120.	W Scorpii	16 5 20	−19 51·0	164.	V Cygni	20 37 45	+47 44·9
121.	R Scorpii	16 11 5	−22 40·3	165.	S Delphini	20 38 1	+16 41·6
122.	S Scorpii.........	16 11 6	−22 37·2	166.	X Cygni	20 39 5	+35 11·4
123.	W Ophiuchi ...	16 15 29	− 7 26·2	167.	T Delphini	20 40 16	+15 59·9
124.	V Ophiuchi ...	16 20 37	−12 10·0	168.	U Capricorni ...	20 42 1	−15 11·3
125.	U Herculis	16 20 57	+19 8·4	169.	T Aquarii	20 44 8	− 5 33·3
126.	Y Scorpii	16 23 17	−19 16·2	170.	T Vulpeculæ ...	20 46 48	+27 50·1
127.	T Ophiuchi......	16 27 26	−15 53·8	171.	Y Cygni	20 47 40	+34 14·7
128.	S Ophiuchi......	16 27 55	−16 55·7	172.	R Vulpeculæ ...	20 59 30	+23 23·2
129.	W Herculis......	16 31 20	+37 33·9	173.	V Capricorni ...	21 1 12	−24 21·7
130.	R Ursæ Min. ...	16 31 27	+72 30·0	174.	X Capricorni ...	21 2 15	−21 47·5
131.	R Draconis ...	16 32 22	+66 59·2	175.	T Cephei.........	21 8 4	+68 2·6
132.	S Herculis	16 46 53	+15 7·6	176.	T Capricorni ...	21 15 57	−15 37·4
133.	R Ophiuchi......	17 1 26	−15 56·6	177.	Y Capricorni ...	21 28 23	−14 27·6
134.	U Ophiuchi......	17 10 56	+ 1 20·0	178.	W Cygni.........	21 31 53	+44 53·0
135.	X Sagittarii ...	17 40 37	−27 47·2	179.	S Cephei	21 36 35	+78 7·7
136.	Y Ophiuchi......	17 46 45	− 6 6·9	180.	U Aquarii	21 57 20	−17 9·4
137.	W Sagittarii ...	17 58 0	−29 35·1	181.	S Piscis Aust ...	21 57 29	−28 34·3
138.	T Herculis	18 4 56	+31 0·1	182.	T Pegasi	22 3 31	+12 0·1
139.	Y Sagittarii......	18 14 55	−18 54·5	183.	δ Cephei	22 25 5	+57 51·1
140.	T Serpentis......	18 23 27	+ 6 13·5	184.	R Lacertæ	22 38 23	+41 47·7
141.	U Sagittarii ...	18 25 25	−19 12·3	185.	S Aquarii	22 51 12	−20 55·7
142.	X Ophiuchi ...	18 33 7	+ 8 43·9	186.	R Pegasi.........	23 1 8	+ 9 57·0
143.	R Scuti	18 41 37	− 5 49·5	187.	S Pegasi	23 14 59	+ 8 19·0
144.	β Lyræ	18 46 1	+33 14·1	188.	R Aquarii	23 38 8	−15 53·7
145.	R Lyræ	18 51 59	+43 48·0	189.	V Cephei	23 51 16	+82 34·7
146.	R Aquilæ	19 1 4	+ 8 3·8	190.	V Ceti............	23 52 16	− 9 34·4
147.	T Sagittarii ...	19 9 53	−17 9·8	191.	R Cassiopeiæ ...	23 52 48	+50 46·5
148.	R Sagittarii ...	19 10 15	−19 30·2				

VARIABLES OF SHORT PERIOD NOT OF THE ALGOL TYPE.

(The No. after Star's Name refers to Catalogue on pp. 24–25.)

Note.—The times of minima only are given; the times of maxima may be found by adding the interval printed under the name of the star.

T MONOCER. 41.

(7^d 22½^h.)

Jan.		May		Sept.	
d	h	d	h	d	h
10	8	25	8	10	9
Feb.		June		Oct.	
6	8	21	8	7	9
Mar.		July		Nov.	
5	8	18	8	3	9
				30	9
Apr.		Aug.		Dec.	
1	8	14	9	27	9
28	8				

ζ GEMINOR. 44.

(5^d 0^h.)

Jan.		Apr.		Sept.	
d	h	d	h	d	h
9	23	11	9	30	23
20	3	21	12	Oct.	
30	7	May		11	3
Feb.		1	16	21	7
9	10	11	20	31	10
19	14	21	23	Nov.	
Mar.		Aug.		10	14
1	18	21	9	20	18
11	21	31	12	30	21
22	1	Sept.		Dec.	
Apr.		10	16	11	1
1	5	20	20	21	5
				31	9

W VIRGINIS 86.

(8^d 4^h.)

Jan.		Feb.		Mar.	
d	h	d	h	d	h
9	5	12	18	2	1
26	12			19	7

W VIRGINIS 86.

(*continued*).

Apr.		July		Nov.	
d	h	d	h	d	h
5	14	18	5	16	2
22	20	Aug.		Dec.	
May		4	11	3	9
10	3	21	18	20	15
27	9	Oct.			
June		12	13		
13	16	29	20		
30	22				

X SAGITTAR. 135.

(2^d 21^h.)

Feb.		May		Aug.	
d	h	d	h	d	h
4	10	13	14	19	18
11	10	20	14	26	18
18	10	27	14	Sept.	
25	11	June		2	18
Mar.		3	15	9	18
4	11	10	15	16	19
11	11	17	15	23	19
18	11	24	15	30	19
25	12	July		Oct.	
Apr.		1	16	7	20
1	12	8	16	14	20
8	12	15	16	21	20
15	13	22	16	28	20
22	13	29	17	Nov.	
29	13	Aug.		4	21
May		5	17	11	21
6	13	12	17	18	21
				25	22

Y OPHIUCHI 136.

(6^d 6^h.)

Jan.		May.		Aug.	
d	h	d	h	d	h
19	17	2	11	13	5
Feb.		19	14	30	8
5	20	June		Sept.	
22	23	5	17	16	11
Mar.		22	20	Oct.	
12	2	July		3	14
29	5	9	23	20	17
Apr.		27	2		
15	8				

W SAGITTAR. 137.

(3^d 0^h.)

Feb.		May		Aug.	
d	h	d	h	d	h
11	8	21	1	20	5
18	22	28	16	27	19
26	12	June		Sept.	
Mar.		5	6	4	9
6	3	12	20	11	23
13	17	20	10	19	14
21	7	28	1	27	4
28	22	July		Oct.	
Apr.		5	15	4	18
5	12	13	5	12	9
13	2	20	20	19	23
20	16	28	10	27	13
28	7	Aug.		Nov.	
May		5	0	4	3
5	21	12	14	11	18
13	11			19	8
				26	22

Y SAGITTAR. 139.

(1^d 19^h.)

Feb.		May		Aug.	
d	h	d	h	d	h
3	13	12	16	18	20
9	7	18	11	24	15
15	2	24	5	30	9
20	21	30	0	Sept.	
26	15	June		5	4
Mar.		4	19	10	23
4	10	10	13	16	17
10	4	16	8	22	12
15	23	22	2	28	6
21	17	27	21	Oct.	
27	12	July		4	1
Apr.		3	16	9	19
2	6	9	10	15	13
8	1	15	4	21	8
13	20	20	23	27	3
19	14	26	18	Nov.	
25	9	Aug.		1	21
May		1	12	7	16
1	3	7	7	13	10
6	22	13	1	19	5
				24	23

U SAGITTAR. 141.

(2^d 23^h.)

Feb.		Apr.		June	
d	h	d	h	d	h
1	15	3	8	3	1
8	9	10	2	9	19
15	3	16	20	16	13
21	21	23	14	23	7
28	15	30	8	30	0
Mar.		May		July	
7	9	7	1	6	18
14	2	13	19	13	12
20	20	20	13	20	6
27	14	27	7	27	0

U SAGITTAR. 141

(*continued*).

Aug.		Sept.		Oct.	
d	h	d	h	d	h
2	18	12	5	22	16
9	12	18	23	29	10
16	5	25	17	Nov.	
22	23	Oct.		5	4
29	17	2	11	11	22
Sept.		9	4	18	16
5	11	15	22	25	10

β LYRÆ 144.

(Max. 3^d 5^h.

Secondary Min.

6^d 11^h.

Max. 9^d 16^h.)

Jan.		May		Sept.	
d	h	d	h	d	h
3	14	12	17	5	23
16	12	25	15	18	21
29	9	June		Oct.	
Feb.		7	13	1	19
11	7	20	11	14	17
24	5	July		27	15
Mar.		3	9	Nov.	
9	3	16	7	9	13
22	1	29	5	22	11
Apr.		Aug.		Dec.	
3	23	11	3	5	9
16	21	24	1	18	7
29	19			31	5

VARIABLES OF SHORT PERIOD (*continued*).

U AQUILÆ 150.

($2^d\ 6^h$.)

Month	d	h
Feb.	17	14
	24	15
Mar.	3	15
	10	16
	17	17
	24	17
	31	18
Apr.	7	19
	14	19
	21	20
	28	20
May	5	21
	12	22
May	19	22
	26	23
June	3	0
	10	0
	17	1
	24	1
July	1	2
	8	3
	15	3
	22	4
	29	5
Aug.	5	5
	12	6
	19	7
	26	7
Sept.	2	8
	9	8
	16	9
	23	10
	30	10
Oct.	7	11
	14	12
	21	12
	28	13
Nov.	4	14
	11	14
	18	15
	25	15
Dec.	2	16

η AQUILÆ 154.

($2^d\ 9^h$.)

Month	d	h
Feb.	5	20
	13	0
Feb.	20	4
	27	9
Mar.	6	13
	13	17

η AQUILÆ 154

(*continued*).

Month	d	h
Mar.	20	21
	28	2
Apr.	4	6
	11	10
	18	14
	25	19
May	2	23
	10	3
	17	7
	24	12
	31	16
June	7	20
	15	0
June	22	4
	29	9
July	6	13
	13	17
	20	21
	28	2
Aug.	4	6
	11	10
	18	14
	25	19
Sept.	1	23
	9	3
	16	7
Sept.	23	11
	30	16
Oct.	7	20
	15	0
	22	4
	29	9
Nov.	5	13
	12	17
	19	21
	27	2
Dec.	4	6
	11	10
	18	4
	25	19

S SAGITTÆ 155.

($3^d\ 10^h$.)

Month	d	h
Feb.	9	20
	18	5
	26	10
Mar.	7	0
	15	9
	23	18
Apr.	1	3
	9	13
	17	22
	26	7

S SAGITTÆ 155

(*continued*).

Month	d	h
May	4	16
	13	1
	21	11
	29	20
June	7	5
	15	14
	23	23
July	2	9
	10	18
July	19	3
	27	12
Aug.	4	21
	13	6
	21	16
	30	1
Sept.	7	10
	15	19
	24	4
Oct.	2	14
	10	23
	19	8
	27	17
Nov.	5	2
	13	12
	21	21
	30	6
Dec.	8	15
	17	0
	25	10

X CYGNI 166.

($6^d\ 19^h$.)

Month	d	h
Jan.	9	19
	26	4
Feb.	11	13
	27	23
Mar.	16	8
Apr.	1	17
	18	3
May	4	12
	20	21
June	6	7
	22	16
July	9	1
	25	11
Aug.	10	20
	27	5
Sept.	12	15
	29	0
Oct.	15	9
	31	19
Nov.	17	4
Dec.	3	13
	19	23

T VULPEC. 170.

($1^d\ 7^h$.)

Month	d	h
Jan.	4	5
	8	16
	13	2
	17	13
	21	23
	26	10
	30	20
Feb.	4	7
	8	17
	13	3
	17	14
	22	0
	26	11
Mar.	2	21
	7	8
	11	18
	16	5
	20	15
	25	2
	29	12
Apr.	2	23
	7	9
	11	20
	16	6
	20	17
	25	3
	29	13
May	4	0
	8	10
	12	21
	17	7
	21	18
	26	4
	30	15
June	4	1
	8	12
	12	22
	17	8
	21	19
	26	6
	30	16
July	5	2
	9	13
	13	23
	18	10
	22	20
	27	7
	31	17
Aug.	5	4
	9	14
	14	1
	18	11
	22	22
	27	8
	31	19
Sept.	5	5
	9	16
	14	2
	18	12
	22	23
	27	9
Oct.	1	20
	6	6
	10	17
	15	3
	19	14
	24	0
	28	11
Nov.	1	21
	6	8
	10	18
	15	5
	19	15
	24	1
	28	12
Dec.	2	22
	7	9
	11	19
	16	6
	20	16
	25	3
	29	13

δ CEPHEI 183.

($1^d\ 15^h$.)

Month	d	h
Jan.	3	7
	8	16
	14	1
	19	10
	24	19
	30	3
Feb.	4	12
	9	21
	15	6
	20	15
	25	23
Mar.	3	8
	8	17
	14	2
	19	11
	24	19
	30	4
Apr.	4	13
	9	22
	15	6
	20	15
	26	0
May	1	9
	6	18
	12	2
	17	11
	22	20
	28	5
June	2	14
	7	22
	13	7
	18	16
	24	1
	29	10
July	4	18
	10	3
	15	12
	20	21
	26	5
	31	14
Aug.	5	23
	11	8
	16	17
	22	1
	27	10
Sept.	1	19
	7	4
	12	13
	17	21
	23	6
	28	15
Oct.	4	0
	9	9
	14	17
	20	2
	25	11
	30	20
Nov.	5	5
	10	13
	15	22
	21	7
	26	16
Dec.	2	0
	7	9
	12	18
	18	3
	23	12
	28	20

MAGNETIC ELEMENTS, ROYAL OBSERVATORY, GREENWICH.

Year.	Declination.	Horizontal force.	Dip.
	° ′		° ′
1870, observed	19 53 west.	0·1782	67 52
1880, „	18 33 „	0·1804	67 36
1890, „	17 29 „	0·1823	67 23
1894, inferred	17 6 „	0·1830	67 17

The horizontal force is given in C. G. S. measure.

MINIMA OF VARIABLE STARS OF THE ALGOL TYPE.

(The figures following star's name are the Nos. in Catalogue, pp. 24–25.)

U CEPHEI 6 *.

(2^d 11^h 50^m.)

Month	d	h	m
Jan.	2	4	48
	7	4	23
	12	4	2
	17	3	42
	22	3	21
	27	3	0
Feb.	1	2	40
	6	2	19
	11	1	59
	16	1	38
	21	1	17
	26	0	56
March.	3	0	36
	8	0	15
	12	59	54
	17	23	33
	22	23	13
	27	22	52
April.	1	22	31
	6	22	10
	11	21	50
	16	21	29
	21	21	9
	26	20	48
May.	1	20	27
	6	20	6
	11	19	46
	16	19	25
	21	19	4
	26	18	44
	31	18	23
June.	5	18	2
	10	17	42
	15	17	21
	20	17	0
	25	16	39
	30	16	19
July.	5	15	58
	10	15	37
	15	15	17
	20	14	56
	25	14	35
	30	14	14
August.	4	13	54
	9	13	33
	14	13	12
	19	12	51
	24	12	31
	29	12	10
Sept.	3	11	49
	8	11	29
	13	11	8
	18	10	47
	23	10	26
	28	10	6
Oct.	3	9	45
	8	9	24
	13	9	4
	18	8	43
	23	8	22
	28	8	1
Nov.	2	7	41
	7	7	18
	12	6	59
	17	6	38
	22	6	18
	27	5	57
Dec.	2	5	36
	7	5	15
	12	4	55
	17	4	34
	22	4	13
	27	3	53

ALGOL 21 *.

(2^d 20^h 49^m.)

Month	d	h	m
Jan.	1	20	13
	7	13	51
	13	7	29
	19	1	7
	24	18	44
	30	12	22
Feb.	5	6	0
	10	23	37
	16	17	15
	22	10	53
	28	4	31
March.	5	22	8
	11	15	46
	17	9	24
	23	3	2
	28	20	39
April.	3	14	17
	9	7	55
	15	1	33
	20	19	10
	26	12	48
June.	22	21	5
	28	14	43
July.	4	8	21
	10	1	59
	15	19	36
	21	13	14
	27	6	52
August.	2	0	28
	7	18	7
	13	11	45
	19	5	23
	24	23	1
	30	16	38
Sept.	5	10	16
	13	3	54
	16	21	32
	22	15	9
	28	8	47
Oct.	4	2	25
	9	20	2
	15	13	40
	21	7	18
	27	0	56
Nov.	1	18	33
	7	12	11
	13	5	49
	18	23	27
	24	17	4
	30	10	42
Dec.	6	4	20
	11	21	48
	17	15	35
	23	9	13
	29	2	51

λ TAURI 23 *.

(3^d 22^h 52^m.)

Month	d	h	m
Jan.	1	2	2
	8	59	46
	16	21	30
	24	19	15
Feb.	1	16	59
	9	14	44
	17	12	28
	25	10	12
March.	5	7	57
	13	5	41
	21	3	26
	29	1	10
July.	1	22	3
	9	19	47
	17	17	32
	25	15	16

λ TAURI 23 *

(*continued*).

Month	d	h	m
August.	2	13	0
	10	10	45
	18	8	29
	26	6	14
Sept.	3	3	58
	11	1	42
	18	23	27
	26	21	11
Oct.	4	18	56
	12	16	40
Oct.	20	14	24
	28	12	9
Nov.	5	9	53
	13	7	38
	21	5	22
	29	3	6
Dec.	7	0	51
	14	22	35
	22	20	20
	30	18	4

R CANIS MAJ. 48†.

$$\left\{\begin{array}{l} 1 = 1^d\ 3^h\ 16^m. \\ 2 = 2\ \ 6\ \ 31 \end{array}\right\}$$

Month	d	h	m
Jan.	6	3	25
	9	13	13
	12	23	0
	16	8	47
	19	18	35
	23	4	22
	26	14	9
	29	23	57
Feb.	2	9	44
	5	19	31
	9	5	18
	12	15	6
	16	0	53
	19	10	40
	22	20	28
	26	6	15
March.	1	6	2
	5	1	50
	8	11	37
	11	21	24
March.	15	7	11
	18	16	59
	22	2	46
	25	12	33
	28	22	21
April.	1	8	8
	4	17	55
	8	3	43
	11	13	30
	14	23	17
	18	9	4
	21	18	52
	25	4	39
	28	14	26
May.	2	0	14
	5	10	1
	8	19	48
	12	5	36
	15	15	23
	19	1	10
	22	10	57
	25	20	45

* Alternate minima only are given; the others can be readily found by adding the interval under the name of the star.

† Every third minimum only.

Minima of Variable Stars of the Algol Type (continued).

R Canis Maj. 48†
(*continued*).

Sept.

d	h	m
2	19	52
6	5	40
9	15	27
13	1	14
16	11	1
19	20	49
23	6	36
26	16	23
30	2	11

Oct.

d	h	m
3	11	58
6	21	45
10	7	33
13	17	20
17	3	7
20	12	54
23	22	42
27	8	29
30	18	16

Nov.

d	h	m
3	4	4
6	13	51
9	23	38
13	9	26
16	19	13
20	5	0
23	14	47
27	0	35
30	10	22

Dec.

d	h	m
3	20	9
7	5	57
10	15	44
14	1	31
17	11	19
20	21	6
24	6	53
27	16	40
31	2	28

S Cancri 61.

Jan.

d	h	m
8	9	39
17	21	17
27	8	55

Feb.

d	h	m
5	20	33
15	8	10
24	19	48

March.

d	h	m
6	7	26
15	19	4
25	6	41

April.

d	h	m
3	18	19
13	5	57
22	17	35

May.

d	h	m
2	5	12
11	16	50
21	4	28
30	16	6

June.

d	h	m
9	3	43
18	15	21
28	2	59

July.

d	h	m
7	14	37
17	2	14
26	13	52

Sept.

d	h	m
2	12	23
12	0	1
21	11	39
30	23	16

Oct.

d	h	m
10	10	54
19	22	32
29	10	10

Nov.

d	h	m
7	21	47
17	9	25
26	21	3

Dec.

d	h	m
6	8	41
15	20	18
25	7	56

δ Libræ 102*.
($2^d\ 7^h\ 51^m$.)

Jan.

d	h	m
1	18	50
6	10	32
11	2	15
15	17	58
20	9	41
25	1	23
29	17	6

Feb.

d	h	m
3	8	49
8	0	32
12	16	14
17	7	57
21	23	40
26	15	23

March.

d	h	m
3	7	6
7	22	48
12	14	31
17	6	14
21	21	57
26	13	39
31	5	22

April.

d	h	m
4	21	5
9	12	48
14	4	30
18	20	13
23	11	56
28	3	39

May.

d	h	m
2	19	21
7	11	4
12	2	47
16	18	30
21	10	12
26	1	55
30	17	38

June.

d	h	m
4	9	21
9	1	3
13	16	46
18	8	29
23	0	12
27	15	55

July.

d	h	m
2	7	37
6	23	20
11	15	3
16	6	46
20	22	28
25	14	11
30	5	54

August.

d	h	m
3	21	37
8	13	19
13	5	2
17	20	45
22	12	28
27	14	10
31	19	53

Sept.

d	h	m
5	11	36
10	3	19
14	19	1
19	10	44
24	2	27
28	18	10

Dec.

d	h	m
5	6	0
9	21	43
14	13	25
19	5	8
23	20	51
28	12	34

U Coronæ 105*.
($3^d\ 10^h\ 51^m$.)

Jan.

d	h	m
4	2	45
11	0	27
17	22	9
24	19	51
31	17	33

Feb.

d	h	m
7	15	15
14	12	58
21	10	40
28	8	22

U Coronæ 105*
(*continued*).

March.

d	h	m
7	6	4
14	3	46
21	1	28
27	23	10

April.

d	h	m
3	20	52
10	18	34
17	16	17
24	13	59

May.

d	h	m
1	11	41
8	9	23
15	7	5
22	4	47
29	2	29

June.

d	h	m
5	0	11
11	21	53
18	19	36
25	17	18

July.

d	h	m
2	15	0
9	12	42
16	10	24
23	8	6
30	5	48

August.

d	h	m
6	3	30
13	1	12
19	22	54
26	20	37

Sept.

d	h	m
2	18	19
9	16	1
16	13	43
23	11	25
30	9	7

Oct.

d	h	m
7	6	49
14	4	31
21	2	13
27	59	55

Nov.

d	h	m
3	21	38
10	19	20
17	17	2
24	14	44

Dec.

d	h	m
1	12	26
8	10	8
15	7	50
22	5	32
29	3	14

U Ophiuchi 134‡.

$$\left\{\begin{array}{l} 1 = 0^d\ 20^h\ 8^m \\ 2 = 1\ \ 16\ \ 16 \\ 3 = 2\ \ 12\ \ 23 \end{array}\right\}$$

Jan.

d	h	m
1	6	37
4	15	8
7	23	39
11	8	9
14	16	40
18	1	11
21	9	42
24	18	13
28	2	44
31	11	14

Feb.

d	h	m
3	19	45
7	4	16
10	12	47
13	21	18
17	5	48
20	14	19
23	22	50
27	7	21

March.

d	h	m
2	15	52
6	0	23
9	8	53
12	17	24
16	1	55
19	10	26
22	18	57
26	3	28
29	11	58

* Alternate minima only are given; the others can be readily found by adding the interval under the name of the star.

† Every third minimum only.

‡ Every fourth minimum only.

Minima of Variable Stars of the Algol Type (continued).

U OPHIUCHI 134 ‡ (*continued*).

Month	d	h	m
April.	1	20	29
	5	5	0
	8	13	31
	11	22	2
	15	6	32
	18	15	3
	21	23	34
	25	8	5
	28	16	36
May.	2	1	7
	5	9	37
	8	18	8
	12	2	39
	15	11	10
	18	19	41
	22	4	12
	25	12	42
	28	21	13
June.	1	5	43
	4	14	15
	7	22	46
	11	7	17
	14	15	47
	18	0	18
	21	8	49
	24	17	20
	28	1	51
July.	1	10	22
	4	18	52
	8	3	23
	11	11	54
	14	20	25
	18	4	56
	21	13	27
	24	21	57
	28	6	28
	31	14	59
August.	3	23	30
	7	8	1
	10	16	32
	14	1	2
	17	9	33
	20	18	4
	24	2	35
	27	11	6
	30	19	37
Sept.	3	4	7
	6	12	38
	9	21	9
	13	5	40
	16	14	11
	19	22	42
	23	7	12
	26	15	43
	30	0	14
Oct.	3	8	45
	6	17	16
	10	1	47
	13	10	17
	16	18	48
	20	3	19
	23	11	50
	26	20	21
	30	4	52

Y CYGNI 171 ‡.

$\left\{\begin{array}{l} 1 = 1^h\ 5^m\ 43^s \\ 2 = 2\ \ 2\ \ 55 \\ 3 = 4\ \ 5\ \ 38 \end{array}\right\}$

Month	d	h	m
Jan.	1	9	55
	7	9	45
	13	9	34
	19	9	24
	25	9	14
	31	9	4
Feb.	6	8	53
	12	8	43
	18	8	33
	24	8	23

Y CYGNI 171 ‡ (*continued*).

Month	d	h	m
March.	2	8	12
	8	8	2
	14	7	52
	20	7	42
	26	7	31
April.	1	7	21
	7	7	11
	13	7	1
	19	6	50
	25	6	40
May.	1	6	30
	7	6	20
	13	6	9
	19	5	59
	25	5	49
	31	5	39
June.	6	5	28
	12	5	18
	18	5	8
	24	4	58
	30	4	47
July.	6	4	37
	12	4	27
	18	4	17
	24	4	6
	30	3	56
August.	5	3	46
	11	3	36
	17	3	25
	23	3	15
	29	3	5
Sept.	4	2	55
	10	2	44
	16	2	34
	22	2	24
	28	2	14
Oct.	4	2	3
	10	1	53
	16	1	43
	22	1	33
	28	1	22
Nov.	3	1	12
	9	1	2
	15	0	52
	21	0	41
	27	0	31
Dec.	3	0	21
	9	0	11
	15	0	0
	20	23	50
	26	23	40

S ANTLIÆ 65 §.

Month	d	h	m
Jan.	1	3	11
	4	8	59
	7	14	47
	10	20	35
	14	2	23
	17	8	11
	20	13	59
	23	19	47
	27	1	35
	30	7	23
Feb.	2	13	11
	5	18	59
	9	0	47
	12	6	35
	15	12	23
	18	18	11
	21	59	59
	25	5	47
	28	11	35

S ANTLIÆ 65 § (*continued*).

Month	d	h	m
March.	3	17	23
	6	23	11
	10	4	59
	13	10	47
	16	16	35
	19	22	23
	23	4	11
	26	9	59
	29	15	47
April.	1	21	35
	5	3	23
	8	9	11
	11	14	59
	14	20	47
	18	2	35
	21	8	23
	24	14	11
	27	19	59
May.	1	1	47
	4	7	35
	7	13	23
	10	19	11
	14	0	59
	17	6	47
	20	12	35
	23	18	23
	27	0	11
	30	5	59
June.	2	11	47
	5	17	35
	8	23	23
	12	5	11
	15	10	59
	18	16	47
	21	22	35
	25	4	23
	28	10	11
July.	1	15	59
	4	21	47
	8	3	35
	11	9	23
	14	15	11
	17	20	59
	21	2	47
	24	8	35
Sept.	1	6	11
	4	11	59
	7	17	47
	10	23	35
	14	5	23
	17	11	11
	20	16	59
	23	22	47
	27	4	35
	30	10	23
Oct.	3	16	11
	6	21	59
	10	3	47
	13	9	35
	16	15	23
	19	21	11
	23	2	59
	26	8	47
	29	14	35
Nov.	1	20	23
	5	2	11
	8	7	59
	11	13	47
	14	19	35
	18	1	23
	21	7	11
	24	12	59
	27	18	47
Dec.	1	0	35
	4	6	23
	7	12	11
	10	17	59
	13	23	47
	17	5	35
	20	11	23
	23	17	11
	26	22	59
	30	4	47

‡ Every fourth minimum only.

§ Every tenth minimum only; the others may be found by adding the multiples of period in the following table:—

P.	h m	P.	d h m	P.	d h m
1	7 47	4	1 7 7	7	2 6 28
2	15 34	5	1 14 54	8	2 14 14
3	23 20	6	1 22 41	9	2 22 1

MAXIMA AND MINIMA OF VARIABLE STARS.

The No. refers to Catalogue on pp. 24–25; M signifies maximum; *m*, minimum.

January.

d	No.	
1	161	*m*
3	27	M
	18	*m*
4	98	M
	151	*m*
	85	*m*
5	152	M
	191	*m*
6	133	M
7	122	M
8	24	M
9	13	*m*
10	129	M
	83	*m*
	7	*m*
	31	M
	147	M
	178	*m*
12	101	M
13	164	M
	146	*m*
14	143	M
15	50	*m*
	142	M
16	40	M
17	189	M
	145	*m*
	161	M
18	26	M
19	120	M
	172	*m*
22	52	M
	37	M
27	131	M
29	96	*m*
30	43	*m*
	4	M
	94	*m*

February.

d	No.	
1	145	M
2	50	M
6	71	*m*
7	156	*m*
	67	*m*
10	149	*m*
13	175	*m*
	57	M
	60	M
14	152	*m*
15	47	*m*
16	49	*m*
	176	M
16	186	*m*
17	14	M
19	51	M
	143	*m*
20	56	M
	177	M
21	16	M
22	95	M
23	169	M
27	3	M
28	140	M
	35	M
	165	M

March.

d	No.	
1	50	*m*
	29	M
3	45	*m*
4	46	M
	12	*m*
	30	*m*
	138	*m*
	145	*m*
5	5	*m*
	10	*m*
6	174	*m*
	126	M
7	59	*m*
8	132	*m*
9	159	*m*
	77	M
10	66	*m*
11	106	*m*
12	24	*m*
	110	M
13	161	*m*
	152	M
16	9	M
18	97	*m*
	149	*m*
19	50	M
	145	M
	83	M
20	92	M
21	109	M
22	172	M
	11	M
	123	M
	99	*m*
24	178	M
26	143	M
	160	M
	108	M
27	53	*m*
28	115	M
	22	*m*
29	161	M
30	163	M
31	94	M

April.

d	No.	
1	118	M
2	85	M
5	95	*m*
	120	*m*
6	157	*m*
10	13	M
11	70	M
12	119	M
15	50	*m*
16	101	*m*
	47	M
18	84	*m*
	173	M
19	145	*m*
20	168	M
23	73	*m*
	152	*m*
25	8	*m*
28	19	*m*

May.

d	No.	
1	103	*m*
	143	*m*
	82	*m*
2	18	M
3	71	M
	50	M
	81	*m*
4	145	M
6	36	M
7	124	M
10	38	*m*
11	89	M
13	25	M
16	34	*m*
17	56	M
18	107	M
	77	*m*
	98	*m*
19	182	M
	152	M
20	159	M
21	178	*m*
	138	M
22	29	*m*
	114	*m*
	161	*m*
24	2	M
28	32	M
29	24	M
	16	*m*
30	50	*m*
31	62	M
	181	M

June.

d	No.	
1	90	M
	68	M
2	185	M
	87	M
3	151	M
	113	M
4	83	*m*
	145	*m*
5	143	M
6	172	*m*
	189	*m*
	146	M
7	161	M
8	96	M
9	131	*m*
12	156	M
13	109	*m*
	125	M
	129	*m*
14	9	*m*
15	153	*m*
17	59	M
	50	M
19	145	M
	35	M
	106	M
20	169	*m*
21	54	*m*
22	43	M
	142	*m*
23	88	*m*
	95	M
	97	M
24	191	M
26	187	M
	100	M
29	112	M
	152	*m*
30	49	M

July.

d	No.	
1	174	M
	176	*m*
	47	*m*
2	80	M
	99	M
	22	M
	45	M
3	5	M
	122	M
4	188	M
5	71	*m*
	101	M
6	149	M
10	94	*m*
	78	M
11	143	*m*
14	10	M
	13	*m*
	50	*m*
18	148	M
19	58	*m*
20	145	*m*
24	116	M
25	4	*m*
26	152	M
	160	*m*
27	67	M
	81	M
28	117	M
29	162	M
30	85	*m*
	121	M
	164	*m*
31	24	*m*
	161	*m*

August.

d	No.	
1	50	M
2	178	M
	159	*m*
3	132	M
4	145	M
5	95	*m*
	51	*m*
	93	M
6	63	M
7	172	M
	16	M
	104	M
	165	*m*
8	73	M
9	84	M
10	66	M
11	56	M
	83	M
13	111	M
	184	M
14	103	M
	128	M
15	143	M
16	138	*m*
	12	M
	179	M
	161	M
17	82	M
	186	M
18	17	M
19	29	M
22	31	*m*
25	175	M
28	157	M
29	50	*m*
	120	M
30	47	M
	180	M
	190	M

September.

d	No.	
1	109	M
2	19	M
4	145	*m*
	152	*m*
5	9	M
	37	*m*
6	55	M
8	94	M
9	167	M
13	39	M
14	177	M
16	50	M
	169	M
18	53	M
19	145	M
20	77	M
	106	*m*
	143	*m*
21	46	*m*
22	18	*m*
	173	M
23	14	*m*
29	10	*m*
	71	M
	178	*m*
	131	M
30	91	M
	98	M

October.

d	No.	
1	152	M
2	11	*m*
4	110	M
	34	M
5	28	M
6	101	*m*
8	35	M
10	174	*m*
	161	*m*
12	79	M
13	50	*m*
	159	M
14	13	M
	70	M
16	129	M
17	24	M
20	114	M
	145	*m*
21	160	M
22	172	*m*
	22	*m*
23	95	M
	92	M
24	96	*m*
	3	*m*
25	143	M
26	161	M
	54	M
	85	M
27	83	*m*
28	119	M
30	156	*m*
31	50	M

November.

d	No.	
2	138	M
	99	*m*
3	148	*m*
4	145	M
	149	*m*
5	133	M
	56	M
6	7	M
8	168	M
	29	*m*
9	127	M
11	8	M
	152	*m*
12	16	*m*
13	176	M
	120	*m*
14	25	*m*
15	47	*m*
18	68	*m*
19	163	*m*
20	26	*m*
	49	*m*
21	58	M
23	158	M
	109	*m*
26	108	*m*
	34	M
27	84	*m*
	50	*m*
28	77	*m*
29	97	*m*
30	71	*m*
	143	*m*

December.

d	No.	
2	146	*m*
3	165	M
	9	*m*
4	153	M
	59	*m*
	95	*m*
5	145	*m*
6	113	*m*
	5	*m*
7	152	M
8	81	*m*
11	52	M
	178	M
12	60	M
15	89	*m*
	50	M
16	40	M
17	94	*m*
	4	M
19	24	*m*
	161	*m*
20	145	M
21	12	*m*
23	172	M
25	103	*m*
	57	M
	101	M
27	122	M
	159	*m*
	38	*m*
29	106	M
30	88	M

DOUBLE STARS.

No.	Name of Star.	R.A. 1890.	Dec. 1890.	Mag.	Pos.-angle.	Distance.	Epoch. 1880+.	Observer.
		h m	° ′		°	″		
1.	Σ 3062	0 0·6	+57 49	6 ; 7	325·2	1·34	10·79	H.
2.	OΣ 4	0 11·1	+35 52	7 ; 8	141·1	0·30	7·93	HΣ.
3.	OΣ 12, λ Cassiop.	0 25·7	+53 55	6½ ; 6½	146·4	0·49	8·97	H.
4.	OΣ 18	0 36·9	+ 3 35	8 ; 10	124·2	1·37	6·97	H.
5.	Σ 52	0 38·0	+45 33	8 ; 9	20·3	1·36	4·08	S.
6.	Σ 60, η Cassiop.	0 42·5	+57 14	3½ ; 7½	191·8	4·79	11·75	M.
7.	OΣ 20, 66 Piscium	0 45·8	+18 36	6 ; 7	341·8	0·4	11·78	L.
8.	Σ 73, 36 Andromedæ	0 48·9	+23 2	6 ; 6½	11·4	1·27	12·98	M.
9.	Σ 113, 42 Ceti	1 14·0	− 1 5	6½ ; 7	352·9	1·48	13·04	M.
10.	Σ 138	1 30·3	+ 7 5	7 ; 7	216·1	1·53	11·08	M.
11.	*p* Eridani	1 35·7	−56 45	6 ; 6	227·2	7·02	10·01	Pk.
12.	Σ 158	1 40·6	+32 37	8 ; 9	255·3	1·92	7·92	H.
13.	Σ 183, AB	1 49·0	+28 15	7 ; 8	2·5	0·51	7·96	H.
14.	Σ 185	1 51·2	+74 55	7 ; 8½	29·9	1·31	1·66	β.
15.	Σ 202, *a* Piscium	1 56·0	+ 2 13	4 ; 4½	321·4	3·01	9·89	M.
16.	Σ 205 Andromedæ	1 57·1	+41 48	4 ; 5	320·1	2·97	7·49	H.
17.	Σ 208, 10 Arietis	1 57·4	+25 24	6½ ; 8½	46·7	1·71	10·03	Kn.
18.	Σ 228	2 6·9	+46 58	6½ ; 7½	51·3	0·33	10·04	H.
19.	Σ 333, ε Arietis	2 52·9	+20 54	5½ ; 6	201·4	1·32	10·99	M.
20.	Σ 367	3 8·3	+ 0 20	7½ ; 7½	230·7	0·66	10·10	T.
21.	Σ 400	3 26·0	+59 39	7 ; 8	316·0	0·62	9·93	H.
22.	Σ 412, 7 Tauri	3 27·9	+24 6	6½ ; 7	216·4	0·30	9·64	β.
23.	Σ 422	3 32·1	+ 0 14	6 ; 8	244·9	6·25	11·68	M.
24.	Σ 460	3 51·7	+80 24	6 ; 7	43·8	0·96	13·21	M.
25.	Σ 511	4 8·7	+58 31	6½ ; 7½	273·3	0·39	10·94	H.
26.	OΣ 79, 55 Tauri	4 13·6	+16 16	6½ ; 8	87·9	0·38	10·67	β.
27.	Σ 535	4 17·2	+11 7	7 ; 8	329·4	1·56	13·14	M.
28.	OΣ 98, *i* Orionis	5 1·9	+ 8 21	5½ ; 7	188·6	1·00	13·19	Ls.
29.	Σ 728	5 24·9	+ 5 52	6 ; 8	179·2	0·38	9·03	β.
30.	Σ 742, 380 Tauri	5 30·6	+21 54	7 ; 8	257·9	3·36	10·11	T.
31.	Σ 749	5 30·3	+26 51	6½ ; 7	167·4	1·20	13·15	Ls.
32.	Σ 945	6 28·6	+41 2	7 ; 8	267·2	0·75	11·09	H.
33.	Σ 948, 12 Lyncis AB	6 36·5	+59 33	6 ; 6½	121·9	1·48	13·21	M.
34.	Σ 982, 38 Geminor.	6 47·9	+13 19	6 ; 8	160·7	6·77	13·22	Ls.
35.	OΣ 159, 15 Lyncis	6 47·8	+58 34	5 ; 6	7·5	0·81	11·09	H.
36.	Σ 1037	7 5·9	+27 25	7 ; 7	306·9	1·07	13·24	M.
37.	ΘΣ 170	7 12·1	+ 9 30	7 ; 7½	112·4	0·74	13·15	Ls.
38.	Σ 1066, δ Geminor.	7 13·5	+22 11	3 ; 8	206·8	7·37	13·21	Ls.
39.	Σ 1074	7 14·8	+ 0 36	7½ ; 8½	144·4	0·70	13·22	Ls.
40.	Σ 1093	7 21·9	+50 12	8 ; 8½	135·6	0·72	11·20	H.
41.	Σ 1110, Castor AB	7 27·6	+32 8	2 ; 3	229·6	5·67	13·19	Ls.
42.	OΣ 182	7 47·2	+ 3 40	8½ ; 8½	31·9	1·26	13·19	Ls.
43.	Σ 1157	7 49·0	− 2 31	8 ; 8	246·2	1·16	12·25	M.
44.	Σ 1187	8 2·6	+32 33	7 ; 8	47·8	2·00	13·15	Ls.
45.	Σ 1196, ζ Cancri AB	8 5·9	+18 0	5 ; 6	26·5	1·05	13·21	Ls.
46.	„ „ AC	……	……	……	116·0	5·23	13·21	Ls.
47.	„ „ BC	……	……	……	131·3	5·17	13·21	Ls.
48.	β 205	8 28·0	−24 14	7 ; 7	256·2	0·65	11·87	β.
49.	Σ 1273, ε Hydræ	8 41·0	+ 6 49	4 ; 7	224·7	3·28	13·24	Ls.
50.	Σ 1306, σ² Ursæ Maj.	9 0·7	+67 35	5 ; 8½	224·4	1·95	9·27	H.
51.	Σ 3121	9 11·3	+29 3	7½ ; 7½	177·3	0·32	13·27	Ls.
52.	Σ 1338	9 13·8	+38 39	7 ; 7½	165·7	1·52	13·28	Ls.
53.	OΣ 201	9 17·3	+28 24	7 ; 11	225·3	1·31	12·32	M.
54.	Σ 1348	9 18·5	+ 6 47	7 ; 8	324·5	1·40	13·26	Ls.
55.	Σ 1356, ω Leonis	9 22·6	+ 9 31	5½ ; 7	102·4	0·77	12·25	M.
56.	Σ 1417	10 9·0	+19 42	8½ ; 8½	257·7	2·56	12·29	M.
57.	OΣ 215, Piazzi x. 23	10 10·3	+18 17	6½ ; 7	209·5	0·95	13·27	Ls.
58.	Σ 1424, γ Leonis AB	10 13·9	+20 24	2 ; 4	115·0	3·73	13·30	Ls.
59.	Σ 1457	10 32·0	+ 6 20	7½ ; 8	316·3	0·86	13·34	Ls.
60.	OΣ 224	10 34·1	+ 9 26	7 ; 9	306·0	0·61	13·31	Ls.

DOUBLE STARS (*continued*).

No.	Name of Star.	R.A. 1890.	Dec. 1890.	Mag.	Pos.-angle.	Distance.	Epoch 1880+.	Observer.
		h m	° ′		°	″		
61.	OΣ 229 …………………	10 43·3	+41 42	6 ; 7	322·9	0·83	12·44	M.
62.	Σ 1523, ξ Ursæ Maj. .	11 12·3	+32 9	4 ; 5	187·3	1·72	13·33	M.
63.	Σ 1536, ι Leonis ……	11 18·2	+11 8	4½ ; 7½	59·6	2·55	13·38	Ls.
64.	OΣ 235 …………………	11 26·1	+61 42	5½ ; 7	86·4	1·04	11·54	M.
65.	Σ 1606 …………………	12 5·3	+40 31	6 ; 7	333·4	1·14	12·49	M.
66.	Σ 1647, 191 Virginis…	12 25·0	+10 10	7½ ; 8	221·5	1·48	12·40	M.
67.	Σ 1670, γ Virginis …	12 36·1	− 0 51	3 ; 3	151·7	5·86	13·32	Ls.
68.	Σ 1687, 35 Comæ……	12 47·9	+21 52	5 ; 8	72·1	1·23	12·42	M.
69.	Σ 1728, 42 Comæ……	13 4·7	+18 7	5½ ; 6	19·5	0·47	13·41	Ls.
70.	OΣ 266 …………………	13 23·1	+16 18	7 ; 8	339·9	1·72	12·50	M.
71.	Σ 1757, Piazzi xiii. 127	13 28·9	+ 0 15	7½ ; 8	80·0	2·62	13·42	Ls.
72.	Σ 1768, 25 Can. Ven. .	13 33·0	+36 46	6 ; 8	143·6	0·93	11·51	M.
73.	Σ 1785 …………………	13 44·2	+27 27	7½ ; 8	249·1	1·71	12·48	M.
74.	Σ 1788 …………………	13 49·0	− 7 31	6½ ; 7½	76·1	2·60	11·12	M.
75.	Σ 1819 …………………	14 9·8	+ 3 39	7½ ; 7½	184·7	1·12	13·47	Ls.
76.	Σ 1865, ζ Boötis ……	14 36·0	+14 12	4 ; 4	289·1	0·47	11·31	β.
77.	Σ 1876 …………………	14 40·8	− 6 55	8 ; 8	251·5	1·30	8·31	L.
78.	Σ 1888, ξ Boötis ……	14 46·3	+19 33	5 ; 7	235·8	2·96	13·47	M.
79.	OΣ 287 …………………	14 47·6	+45 22	7 ; 8	321·9	0·94	13·49	Ls.
80.	β 239…………………	14 52·0	−27 12	6 ; 6	311·4	0·86	9·44	β.
81.	β 119…………………	14 59·7	− 6 35	8 ; 8½	306·4	1·61	8·45	L.
82.	Σ 1932, 1 Cor. Bor.…	15 13·5	+27 15	6½ ; 7	317·3	0·94	13·50	Ls.
83.	Σ 1937, η Cor. Bor.…	15 18·6	+30 41	6 ; 6	222·0	0·75	11·54	M.
84.	Σ 1938, μ^2 Boötis……	15 20·3	+37 46	6½ ; 7½	88·6	0·77	13·49	M.
85.	OΣ 298 …………………	15 32·5	+40 13	7 ; 7½	167·2	0·68	11·48	H.
86.	Σ 1967, γ Cor. Bor.…	15 35·0	+37 0	4 ; 7	125·6	0·36	11·51	H.
87.	OΣ 303 …………………	15 56·0	+13 35	7 ; 7½	139·9	0·97	11·52	M.
88.	Σ 1998, ξ Scorpii ……	15 57·7	−11 4	5 ; 5½	208·0	1·23	12·53	M.
89.	Σ 2032, σ Coronæ……	16 11·0	+34 12	6 ; 6½	209·8	4·24	13·62	M.
90.	Σ 2055, λ Ophiuchi …	16 25·0	+ 2 13	4½ ; 5½	44·2	1·65	11·64	M.
91.	Σ 2084, ζ Herculis …	16 37·2	+31 48	3 ; 6½	57·4	1·35	12·61	M.
92.	Σ 2107, 167 Herculis .	16 47·6	+28 52	7 ; 8½	254·1	0·38	8·60	H.
93.	Σ 2173, 221 Ophiuchi.	17 24·5	− 0 58	6 ; 6	340·7	0·91	12·72	M.
94.	OΣ 338 …………………	17 47·0	+15 21	6½ ; 6½	21·2	0·84	9·73	M.
95.	Σ 2262, τ Ophiuchi …	17 57·1	− 8 11	5 ; 6	253·9	1·84	13·47	M.
96.	Σ 2272, 70 Ophiuchi .	18 0·0	+ 2 33	4 ; 6	313·8	2·22	13·47	M.
97.	OΣ 358 …………………	18 31·0	+16 50	6½ ; 7	198·4	1·73	8·74	M.
98.	Σ 2382, ϵ_1 Lyræ ……	18 40·8	+39 34	5 ; 5½	12·5	3·35	10·45	G.
99.	Σ 2383, ϵ_2 Lyræ (5)…	18 40·8	+39 29	5 ; 5½	131·4	3·04	10·45	G.
100.	γ Coronæ Australis …	18 59·0	−37 14	5½ ; 5½	176·9	1·68	11·53	β.
101.	β 248…………………	19 12·9	+22 51	6 ; 9	125·4	1·86	10·63	β.
102.	Schjellerup 30 ………	19 21·5	−12 22	8 ; 8	328·3	1·60	8·54	L.
103.	Σ 2579, δ Cygni ……	19 41·5	+44 50	3 ; 8	316·1	1·62	10·56	M.
104.	OΣ 387 …………………	19 44·5	+35 2	7 ; 8	354·6	0·55	8·76	HΣ.
105.	β 151, β Delphini …	20 32·4	+14 13	3½ ; 5½	331·6	0·38	11·45	β.
106.	OΣ 413, λ Cygni ……	20 43·1	+36 8	5 ; 7½	70·5	0·66	9·86	M.
107.	Σ 2729 …………………	20 46·0	− 6 2	6½ ; 6½	184·5	0·55	12·70	T.
108.	Σ 2799 …………………	21 23·3	+10 36	7 ; 7½	302·9	1·35	9·94	M.
109.	β 170…………………	22 3·0	−19 1	8 ; 8	60·4	1·56	8·78	L.
110.	Σ 2909, ζ Aquarii……	22 23·2	− 0 36	4 ; 4	322·9	3·26	13·83	M.
111.	Σ 2944, AB ………	22 42·1	− 4 48	7 ; 7½	255·5	3·50	12·76	M.
112.	OΣ 483, 52 Pegasi……	22 53·0	+11 7	6 ; 7½	216·9	1·10	11·29	M.
113.	β 79 …………………	23 11·4	− 2 10	8 ; 8½	94·6	0·88	11·54	β.
114.	β 80 …………………	23 12·7	+ 4 45	8 ; 8½	322·5	0·69	11·57	β.
115.	OΣ 547 …………………	23 59·5	+45 11	8 ; 8	340·8	4·30	11·73	H.

In the column headed "Observer," the following abbreviations are used:—

L.	Leavenworth.	G.	Glasenapp.	H.	Hall.	T.	Tarrant.
S.	Seabroke.	β.	Burnham.	Kn.	Knorre.	Ls.	Lewis.
HΣ.	Herman Struve.	M.	Maw.	Pk.	Pollock.		

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 210. JANUARY. 1894.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, December 8, 1893.

Capt. Abney, F.R.S., *President*, in the Chair.

Secretaries: H. H. Turner, M.A., B.Sc., and E. W. Maunder.

The Minutes of the last Meeting were read and confirmed.

Mr. Maunder. 75 presents have been received since the last Meeting. Two of these are Tables of Logarithms, presented by General Tennant. Prof. A. Cayley presents the sixth volume of his collected Mathematical Papers, and Prof. Bakhuyzen has sent a very beautiful study of the Milky Way in the Northern Hemisphere by Mr. C. Easton, consisting of five lithographic plates, with detailed description, catalogue, and historical notes.

Thanks were passed to the donors.

Messrs. Cottam, Gibbs, and Inwards were appointed auditors of the Society's accounts for the past year.

Mr. Turner read a paper by *Mr. Jacoby*, in the course of which he said that Mr. Jacoby had called attention to an important discovery by Dr. Wilson of the periodic variation in the distance of the components of 61 Cygni. Mr. Jacoby gave the results of his measures in the form of a table, which indicated good agreement between the independent determinations A and B. The measures of Prof. Pritchard's results agreed fairly well with those of Dr. Wilson. On the whole, it might be concluded that the evidence furnished by the Oxford measures was favourable to the theory of Dr. Wilson's discovery.

Mr. Turner then read a paper by *Mr. S. W. Burnham* on the double star γ Andromedæ. The author stated that for nearly 40 years after the discovery of this double star measures failed to show any change in angle or distance. Ten years ago it was evident that the distance was decreasing, and the pair obviously called for observation, and Mr. Burnham during the past summer requested Prof. Barnard to observe the star with the 6-inch telescope. Prof. Barnard made two examinations, and on both occasions he was absolutely certain that the smaller component was on the following side. Mr. Turner passed round a diagram showing the orbit of the star for the inspection of the Meeting, and said that from this diagram Fellows would be able to appreciate the value of Mr. Barnard's new measures, which made it possible to determine anything like an orbit from such a complication of measures as those for the earlier years. Mr. Burnham's retirement from the labour of observation seemed to have given him leisure to consider points in the theory of double stars.

Mr. Turner then made some remarks on his paper on the measurement of the plates of the Astrographic Chart, which had been already printed in the 'Monthly Notices,' and which he had intended to refer to at the last Meeting. He explained that there seemed to be no reason why Right Ascension and Declination should be used for these measures in preference to any other system of coordinates, and pointed out that rectangular coordinates, with the centre of the plate as origin, would be sufficient for all practical purposes, and that the measurement and publication of such would entail much less work than a system which aimed at publishing the R.A. and Dec. of all stars on the plates.

In answer to a question by Mr. Stone, Mr. Turner said:—My point is that the great bulk of the stars should be left defined only by these coordinates. For some comparatively few stars, say those of the proposed catalogue, these coordinates should be transformed into R.A. and Dec. as well. If it were necessary to know the R.A. and Dec. of other stars for any purpose, perhaps to define the path of a comet, such could easily be found from the rectangular coordinates. If the whole of the stars of the Photographic Chart are transformed into R.A. and Dec. that is doing ten times the work which is required to find rectangular coordinates for the few thousand already known. Similarly, for any purpose, the transformation can be effected for the few stars concerned. It seems to me the material will be in a very convenient form for use, and yet useless labour will not be undertaken in doing for all the stars what only may be required for a very few.

Dr. Downing. There are two questions I should like to ask Prof. Turner, not in any spirit of criticism, but merely to obtain information. Is it necessary to have the optical axis of the telescope at right angles to the plate? and if it is necessary, can any error of that kind be readily allowed for? Secondly, I believe the corrections for refraction and distortion are put in a linear form. Does that embrace the full correction, or does that omit the part of the corrections of the second order?

Mr. Turner. With regard to the first question, with respect to every plate there are three points which might be called the centre. First of all there is the geometrical centre of the plate; secondly, there is the line where the optical axis of the object-glass would cut the plate, which changes as you tilt the object-glass; and thirdly, there is the line where a perpendicular line from the centre of the object-glass would cut the plate, which changes as you tilt the plate. I must confess at the present moment I am not clear how the second of those centres may be readily detected, that is to say the point where the optical axis of the object-glass cuts the plate. I am not aware how the non-symmetry of images resulting from the plate being tilted would be distinguished from the image where the plate is not tilted. At the moment I do not quite know about that. On this point I am clear, that the optical phenomena of distortion with which we have to deal group themselves about the third centre—that is, the point where the perpendicular from the centre of the object-glass falls on the plane of the plate; and I am clear that it is very important to have the plate at right angles to the line from the centre of the object-glass to the centre of the réseau, or at least to know where the foot of the perpendicular on the plane of the plate from the centre of the object-glass falls upon the plate. An error in this adjustment amounting to 20 minutes of arc might introduce an error of 1½ or 2 secs. of arc at the corners. For less than 20 min. of arc the magnitude of the error will decrease as the square of the distance from the centre. I have made experiments, together with Mr. Criswick, with the Greenwich telescope, and I find it is easy to adjust the plate within a very few millimetres. I must say we found the plate in very good adjustment, and it is an adjustment to which they paid particular attention in Paris; but if that adjustment is properly made I do not think there is the slightest difficulty in applying linear equations or the slightest error in using them. With regard to refraction and aberration, I am indebted to a paper by Dr. Rambaut, who is here this evening, in which it is pointed out that these quantities need only be retained to the first order. If that is once proved, it is a proof that the lines on the plate are still straight lines, although the stars may be affected by refraction and aberration. That, of course, assumes that the plate is not taken below a certain zenith-distance, and I leave it to Dr. Rambaut to say what that zenith-distance is; but I know this, the zenith-distance is considerably greater than that which we are contemplating in the chart work.

Dr. Rambaut. This matter has already occupied the attention of Sir Robert Ball and myself in a paper which we read before the Royal Irish Academy, and we showed that with a telescope of 10 ft. 6 inches focal length it was sufficient to determine the centre within 5 or 6 min. of arc, and with that amount of accuracy an error due to an erroneous determination of the centre would not be felt when measuring distances amounting to 2000 seconds. With regard to the limits of zenith-distance at which the refraction correction need only to be computed to the first order of small quantities, as the paper to which Prof. Turner refers is not very fresh in my memory, I cannot mention the figures just now; but in that paper I gave the limits within which terms of second degree might be neglected, and in no case, to the best of my recollection, was it necessary to take into account the terms of the second order, if the zenith-distance were less than 60°.

Dr. Isaac Roberts exhibited and described photographs of the Nebulæ Herschel I. 205 Ursæ Majoris, and of Herschel I. 168 Ursæ Majoris.

Capt. Noble. To what does Dr. Roberts attribute the elliptical form of the stars? In one photograph they are circular, and in another they are notably elliptical.

Dr. Roberts. I will throw the positive on the screen again. The exposure of this photograph was four hours and the enlargement is great. During four hours' exposure, if there is any deviation whatever in the clock or the correction be not quite perfect, the stars will be slightly elongated. The bright stars fill up and appear round, but the fainter ones are slightly elliptical in this case. That is the explanation. Sometimes it is an advantage to be able to distinguish stars from specks, and I do not consider a little elongation a defect, because then we are sure we are not mistaking spots or specks on the film for stars.

Mr. Ranyard. There is one remark which it is perhaps worth while to make as to this very beautiful and very regular nebula. The spiral streams are not merely spiral, but the one towards the north was seen to branch. One can conceive of a stream being shot forth so as to form an equiangular spiral if the stream issued from a revolving body. For example, supposing a beam of light as from an electric light was shot out from a lighthouse at the Earth's pole, and that it revolved in a plane parallel to the plane of the Moon's orbit once in a second, as seen from a distance such a ray of light, if it fell upon an atmosphere in space, would be seen from a distance not as a straight ray but as a spiral curve, in fact the spiral of Archimedes; and there would be a complete turn and a third before it reached the distance of the Moon's orbit, because light takes about $1\frac{1}{3}$ seconds to travel from the Earth to the Moon; the light issuing at any instant would travel in a different direction to that shot forth previously or subsequently. But the curious branch seen in the ray towards the north in this photograph of Dr. Isaac Roberts shows that there can be no such simple explanation of the regular structure in this nebulæ.

The President then called upon *Dr. Rambaut* to read his paper on the adjustment of the polar axis of an equatorial telescope for photographic purposes.

Dr. Rambaut said:—An equatorial telescope, when intended for ordinary visual purposes, is generally considered to be in sufficient adjustment as regards the errors of polar axis in altitude and azimuth if these do not exceed more than a minute of arc. In fact the ordinary method of adjusting such an instrument by means of the readings of the declination circle is in general not susceptible of a higher accuracy unless very elaborate precautions are taken to eliminate the effect of the flexure. A method by which the axis of an equatorial telescope for photographic work may be adjusted to a high degree of accuracy has been pointed out by Dr. Scheiner. It has the disadvantage that the adjustment has to be made during the course of observations which are affected by the variation of the refraction. In the method which I propose, however, the position of the axis may be determined by measures of a photograph on which two short exposures on the same star have been taken at intervals of about 15 or 30 minutes, the driving-clock of the telescope being allowed to run without hand-correction in the interval, and the effect of the refraction may be allowed for with any degree of accuracy that is thought desirable. A very convenient means of allowing for this is given in the paper in the 'Astronomische Nachrichten' which has been referred to. Not to trouble the Meeting with the details of the calculation, I may state, which perhaps the members of the Society will take on trust until they have had an opportunity of reading the paper in print, that if θ be the hour-angle of the point to which the telescope is directed, and if dt is the increment of time, the expression $d(\theta-t)$ (which is the amount which the pointing of the telescope gains on the star in the interval) may be represented by the formula $\lambda \tan \delta \sin(\theta+h)\, dt$. Now that expression shows that if the declination of the star be anything considerable, then in as short a period as ten minutes if λ is not less than a minute of arc, the error of the clock in following the star, or the amount by which the telescope falls behind or precedes the star, may amount to as much as a sec. of arc, showing therefore that the adjustment of the instrument should be done with considerable accuracy. Also the error introduced in the declination may be represented by the expression $-\lambda \cos(\theta+h)\, dt$. This shows that no matter how accurately the clock may run, if the instrument is not adjusted with greater precision than the ordinary method allows, no clock can possibly follow the star with accuracy.

Dr. Rambaut then proceeded to explain his formulæ and methods.

Mr. Turner. I am very much interested in this subject. Almost an infinite number of points seem to arise on every hand in connection with the work of the Photographic Chart, and this is one of them. I have hardly had time to digest Dr. Rambaut's paper, although he kindly sent it to me a few days ago. The adjustment of the equatorial appears to different people in different ways, and the geometrical idea of the problem occurred to me as no doubt it did to others; and I have not been able quite to translate my ideas into Dr. Rambaut's formulæ. If you have a rotation about an axis which does not quite coincide with the original one, or is not quite parallel to it and in the opposite direction, you will get a rotation about an axis very nearly perpendicular to the two rotations combined, very much as two forces would combine. Generally, if a telescope is pointing to the pole, and not to the equator, then any axis which is perpendicular to its length will cause a slight travelling of the stars, as the exposure is prolonged. Each of the stars ought to be a little line when the telescope is pointing to the pole and the clock allowed to drive, and this ought to give us the result of the error of the polar axis. It seems to me that pointing the telescope to the pole, the direction of the travelling of the star-images ought to give us some notion as to the relative and absolute magnitude of these errors. This, however, is an idea which I have not had time thoroughly to digest since Dr. Rambaut began to talk about it, and I cannot say how far any method of this kind would be comparable with the method he has deduced so very ably from the formula.

The Astronomer Royal. This is a question of great practical importance in the application of long exposures to astronomical work, and I am pleased that Dr. Rambaut has brought the matter before the meeting. It is a question which Dr. Rambaut called my attention to, but we had already been to a certain extent acquainted with the importance of it, and we had adopted a plan for the adjustment of the equatorial, which I think has also been proposed by some one on the Continent, which gives you, by means of photography, a very accurate means of adjusting the polar axis of the telescope. It comes to this. As Prof. Turner has just explained, he and I discussed this question and we were struck with this point: when we took a photograph of the pole with a clock driving, we found that all the stars gave little parallel lines. On considering the point it appeared that those lines represented the motion of the heavens about the pole of the instrument. As the instrument rotates with the driving-clock, any irregularities of the clock-driving have practically no influence upon the arcs described by the stars near the pole. We may get the clock-driving sufficiently perfectly for a plate within a degree of the pole to give the stars perfectly round disks provided the pole of the instrument is adjusted accurately to the pole of the heavens; but if it is not, and there happens to be a star at the point which we may call the pole of the instrument, the turning of the clock-work will produce no effect on that star. It will remain always in the same position, but it will turn naturally about the pole of the heavens; so the conclusion we came to was this:—we gave a certain exposure with the clock-driving, and then we got trails of stars, all of which indicate the deviation of the pole of the instrument from the pole of the heavens. By working in a geometrical manner we have been able to correct the adjustment of our polar axis, so that all images of stars are sensible circles with an exposure of 30 minutes. Dr. Rambaut wrote to me about this subject, and I wish to acknowledge the assistance he has given me in calling my attention to it pointedly. This was a thing we had taken up some time ago; but until Dr. Rambaut wrote I did not realize that this would apply all over the heavens, and that whenever there is an error of this sort we shall get a star at any point of the heavens represented by a straight line instead of by a circular disk. As Dr. Rambaut has pointed out, it is necessary to adjust the polar axis within a very few seconds of arc for this work. Photography requires this very accurate adjustment, and at the same time gives us the means of effecting it.

Dr. Rambaut. I would express the hope that Prof. Turner will look into this, when he finds leisure, from a geometrical point of view. I think there is a great advantage in getting a geometrical view of this question.

The President. I think I shall be able to show you another difficulty which arises in photography is estimating values from star-negatives. The more we thresh out this question of stellar photography the more exact we shall be able to get our results. I am far from opinion at present that the exactitude which is required in this direction has been obtained, and we have proof here that there are certain other quantities which have to be taken into account.

The President. We have with us to-night a distinguished American, Mr. Alvan G. Clark, and I am sure I have only to mention his name to the R.A.S. for him to receive a hearty welcome from all; and I will ask Mr. Clark to say a few words to the Society.

Mr. Alvan G. Clark. I esteem it a very great honour to be asked to speak to this assembly. I had no idea of receiving such an honour when I left my home to cross the Atlantic Ocean; but I would like to tell you what we are doing in the way of astronomical telescopes at the present time. We have just finished and set up at the Harvard Observatory what is called the Miss Bruce photographic telescope; and feeling that I required to recruit my health, I decided to cross the Atlantic. I know of no place where I can rest so well as on the Atlantic Ocean [laughter], for I generally sleep well at sea. After this instrument was mounted eight different plates were taken with it at the Harvard Observatory. These plates were 11 × 14 inches, the lens itself is 24 inches clear aperture, and a focal length of 11 ft. 3 in., very short indeed. What I saw of the images convinced me that it was going to be as great a success as I could have anticipated, and I felt it was safe to leave it, after asking Prof. Pickering to write to me, as soon as he had the instrument perfectly adjusted, regarding the result. I have a letter in which he states that he took several photographs after I left. He says: "A number of photographic plates were obtained last night with the Bruce telescope; they were better than those you have seen; the images even at the edge of the plate were fairly good and better than I had supposed at first; but the telescope is not yet in adjustment, so that the faint stars do not appear." I have no doubt in my own mind regarding the faint stars; I think that the glass is going to show the faint stars well because it photographs the trails of faint stars. Before it was carried to Cambridge we took a good many stars near the Pole. There is a little star near the Pole where there are three very close together and in the 24-inch glass the trails are much divided and much plainer than in the 8-inch. The trails are three times as dense in the same time. If that time is condensed by the clock-work, we expect to take very faint stars, and I think we have the very best of reasons to expect it. It is an enormous instrument. The glasses themselves average 100 lbs. each, that is 400 lbs. of fine optical glass in the telescope besides the prism. The prism, which is to go in front, is already made but has not yet been tested photographically. It weighs 130 lbs., is 3 inches thick at one end and ⅞ inch thick at the other. This instrument is all ready for work now, and I am expecting every day to hear some further results. Now I will speak of the 40-inch glass clear aperture which we are at work upon. In its present condition the surfaces are all well polished, the centering is very nicely done, and I am perfectly satisfied with the chromatic correction; but the spherical aberration is a matter requiring a good deal of care yet. I have to put on our local corrections (a tentative process), but I do not want to commence on that until we get warmer weather in the spring. The disks were made by Mantois, of Paris, and there is scarcely any imperfection in the two great disks, and in the crown itself there is nothing that I have been able to observe. There is a little striæ on the glass; the flint glass is free from polarization, and the glasses generally promise better than any of the larger glasses we have ever undertaken.

Dr. Common. There is one question I am sure Mr. Clark will not mind answering. What form is the combination of the two lenses of the Bruce telescope? Do they form an ordinary symmetrical double combination?

Mr. Clark. It is an ordinary double combination and would come nearer to what is known in the market as a rapid portrait-lens. The surfaces are not symmetrical; the two pairs are quite different.

Mr. Ranyard. What is the thickness, in the Yerkes telescope, of the crown and flint glasses respectively?

Mr. Clurk. I think the crown glass is 3 inches and the flint 1½ inches.

Mr. Ranyard. And at the edge what is the flint?

Mr. Clark. At the edge the crown is about ⅞ of an inch and the flint 2¾ inches.

A Fellow. Do the lenses touch each other or are they separate?

Mr. Clark. They are separate,—all of them. The separation in the Bruce telescope is ¼ inch, and 2½ inches from the back.

Mr. Ranyard. What is the shape of the image at the edge of the field in the Bruce telescope? How does it differ from a circle? Has the star image at the edge of the field a single tail or a cross form?

Mr. Clark. It would be a cross if you went out far enough; but we hope to get 5 degrees without any crosses.

Mr. Freeman. Does Mr. Clark consider that as the glass becomes greater and greater the element of absorption becomes serious? and whether the amount of light lost by these thicker lenses will put a stop to the enlargement of apertures of refracting telescopes?

Mr. Clark. I am very glad that question has been asked. I have never seen any deterioration from absorption in the different sizes. Of course there is absorption in the small glasses, and it would seem that if you double the thickness you double that absorption, but I am not sure you do. Mathematicians can tell you better about that; but I do know from practical experience when we started to increase the size of the refracting telescope we commenced with 18½ inches aperture and that certainly had so much advantage over the 15½-inch that it encouraged people to get something larger. The next largest we made was 26 inches for the Washington Observatory and another of the same size for the Observatory in Virginia. The light-gathering power seemed to increase in proportion. After that we made a 30-inch and that gave us a great deal more light, more separating power, and was vastly superior to the 26-inch. Then we made a 36-inch, which was certainly superior to the 30-inch, and I have every reason to suppose that the 40-inch will be superior to the 36-inch. I think you will find this matter of the absorption by the thickness of the glass has, by many people, been over-estimated. From practical experience I should think that it has.

Capt. Noble. How is the 40-inch telescope lens supported at the edge?

Mr. Clark. It is supported on the edge on a continuous barrel. It is fitted in a cast-iron cell, and that cell has a ring of silver dovetailed in, and the barrel on the glass is silver. There is a looseness of the glass in warm weather of 100th of an inch. We have always rested them on triangular barrels. We have not found it necessary to put in intermediate supports with the 36-inch. If we find it necessary we shall have to put in intermediate barrels with counterpoising weights.

A vote of thanks was passed to Mr. Clark.

Father Sidgreaves then exhibited and explained some photographs he had taken of β Lyræ.

At the suggestion of Mr. Turner, it was agreed to prolong the sitting till half-past ten in order to hear Capt. Abney's paper on "Errors that may arise in Estimating Stellar Magnitudes by Photography."

The President then read his paper.

The following papers were announced and partly read:—

Isaac Roberts. "Photographs of the Nebulæ ♅ I. 168 and 205 Ursæ Majoris."

A. Stanley Williams. "On the rotation of Saturn."

Sydney Observatory. "Observations of Double Stars."

S. W. Burnham. "The Orbit of γ Andromedæ, BC.

Rev. W. Sidgreaves. "The Variable Spectrum of β Lyræ in the region F—*h*."

John Tebbutt. "Windsor observations of α Centauri."

Rev. T. E. Espin. "Note on the Spectra of certain Red Stars."

Rev. T. E. Espin. "Two new Variable Stars."

H. Jacoby. "The Periodic Variation in the Motion of 61 Cygni."

Dr. A. A. Rambaut. "To adjust the Polar Axis of an Equatorial Telescope for Photographic Purposes."

Lieut.-Col. E. E. Markwick. "Observations of the Variable Stars W and X Sagittarii."

Royal Observatory, Greenwich. "Observations of Brooks's Comet (*c* 1893)."

T. C. Hudson. "Note on a Star-Correction Facilitator, or an Instrument for readily obtaining the Products of pairs of Numbers,"

Capt. W. de W. Abney. "On Errors that arise in Estimating Stellar Magnitudes by Photography."

The following gentlemen were elected Fellows of the Society:—

Capt. Edmond Herbert Hills, R.E., 1 Devonshire Place, W.; *Charles Herbert Edmund Rea*, 223 Norwood Rd., Herne Hill, S.E.; *William Shackleton*, Royal College of Science, S. Kensington, S.W.

The following Candidate was proposed for election as Fellow of the Society:—

Wm. Ford Stanley, F.G.S., F.R.Met.Soc., Cumberlow, South Norwood, S.E. (proposed by T. Cushing).

ROYAL METEOROLOGICAL SOCIETY.

The Monthly Meeting of this Society was held on Wednesday evening, December 20th, at the Institution of Civil Engineers, 25 Great George Street, Westminster; Dr. C. Theodore Williams, President, in the Chair.

Mr. C. Harding, F.R.Met.Soc., gave an account of the "Great Storm of November 16th to 20th, 1893." This storm was the most violent of recent years, and, so far as anemometrical records are concerned, the wind attained a greater velocity than has previously been recorded in the British Islands. The velocity of the wind was 96 miles in the hour from 8.30 to 9.30 P.M., Nov. 16th, in the Orkneys, where the hurricane burst with such suddenness that it is described as like the shot of a gun; and the wind afterwards attained the very high rate of 90 miles and upwards, in the hour, for 5 consecutive hours. At Holyhead the storm was terrific, the anemometer recorded a wind velocity of 89 miles in the hour, and it was 80 miles or above for 11 hours, while the force of a whole gale, 65 miles an hour and upwards, was maintained for 31 hours, and for 4½ days the mean hourly velocity was 54 miles. Many of the gusts were at the rate of 115 miles an hour, and at Fleetwood a squall occurred with the wind at the rate of 120 miles in the hour. The storm was felt over the entire area of the United Kingdom; and the wreck returns show that disasters occurred with almost equal frequency on all coasts. Four weeks after the storm the official records gave the total loss of life on our coasts as 335, while there were 140 vessels which had been abandoned, or had foundered, stranded, or met with other severe casualty, involving either loss of life, or saving of life by some extraneous assistance. There were 600 lives saved on our coasts by aid of the Lifeboat Institution and other means. The author has tracked the storm from the neighbourhood of the Bahamas on Nov. 7th, across the Atlantic, and over the British Islands to Central Europe on Nov. 20th.

The other papers read were: "Rainfall and Evaporation Observations at the Bombay Water Works," by Mr. S. Tomlinson, M.Inst.C.E.; and "On Changes in the Character of certain Months," by Mr. A. E. Watson, B.A., F.R.Met.Soc.

Meteor of November 12, 1893.

On Nov. 12, at about $6^h\ 50^m$, Mr. H. J. Townshend, of Leeds, observed a meteor exceeding Jupiter in brightness, and passing, "with a slow and heavy motion," in a horizontal direction along the southern region of Pegasus. Its exact path was noted as from $347° + 7°$ to $325° + 6°$, and the meteor left a broad stream of greenish-yellow light in its wake, "as if the body was breaking up in its passage, till it suddenly exploded like a rocket and its incandescent fragments of reddish green and yellow lit up the vicinity momentarily and brilliantly."

On the same evening at $6^h\ 53^m$ I saw, at Bristol, a very slow yellow meteor traversing a path of 23° in Auriga and the Lynx, or, more precisely, from $81\frac{1}{2}° + 42°$ to $113° + 50\frac{1}{2}°$. The meteor passed very close to β Aurigæ, and was then about 1st mag., but its light fluctuated considerably and it was not brighter than 2nd mag. during the greater part of its flight. I estimated its duration as 4 seconds, the motion being exceptionally slow.

On comparing the two observations it is evident they relate to the same meteor, though it must have been seen at Bristol much earlier in its path than at Leeds. I have deduced the following details respecting it:—

Height of meteor when first observed at Bristol..	66 miles.
Height when last observed at Leeds	36 „
Entire length of observed real path	91 „
Inclination of path to mean horizon............	19°
Radiant-point...........................	40° +6°

The earth-point is indicated in the Irish Sea in lat. 53° 36′ N., long. 4° 30′ W. 71 miles of the path were observed at Bristol, and the resulting velocity is 18 miles per second, but an estimate by the Leeds observer makes it much less. When first seen the meteor was above a point in "The Wash" about 8 miles N.W. of Lynn Regis, Norfolk, and pursuing a course a little N. of W. it disappeared near Bakewell, Derbyshire.

The fact that the meteor appeared much brighter to the Leeds observer is explained by the circumstance that at its disappearance it was not more than 42 miles distant from Leeds, whereas it was some 127 miles from Bristol. It would therefore appear 9 times as bright at Leeds, and no doubt the streak and other details would be much better displayed there than at Bristol, on account of their relative proximity.

When the meteor came under observation at Leeds it had already completed a considerable portion of its luminous flight. Mr. Townshend was not watching for meteors at the time, but was walking along a road and had just passed under the glare of a street lamp when the meteor first caught his eye.

The radiant-point is in the head of Cetus and forms the apex of a triangle with α and γ Ceti. It may be connected with the following positions:—

Radiant.	Date.	Observer.
40° +6°	Oct. 30, 1872.	Backhouse.
46 +1	Nov. 1–14.	Heis.
45 +5	Nov. 19, 1861.	A. S. Herschel.

The last of these represents the radiant of a fireball. I have never obtained a good view of these Cetids in November, but have remarked them several times in October, and fixed the radiant 2° or 3° N. of α Ceti.

W. F. DENNING.

The "Gegenschein," or Zodiacal Counterglow.

PROF. BARNARD has an interesting paper on this curious object in the 'Astronomical Journal,' No. 308, and the following has been abstracted from his remarks.

"It will be well here to briefly state a few of the facts that have been brought forth during my observations, which extend over an interval of ten years.

"In July the 'Gegenschein' is small and round, less than 10° in diameter. After crossing the Milky Way in the Scorpion and

Sagittarius it is largest—some 20° in diameter; round, and gradually brighter in the middle; dense and hazy. It is then not connected with any zodiacal band. It remains thus without special change until September and October, when near the vernal equinox. Here it becomes elongated along the ecliptic, and is connected with a narrow elongated band which is some 4° in width. After this the ‘Gegenschein’ narrows down very much, until by November and February it is reduced to simply a swelling and intensification of the zodiacal band, and is only 5° or 6° in breadth north and south; and in general it remains thus until April. At two points in its path it is lost in the Milky Way—in Sagittarius and in Gemini.

“The ‘Gegenschein’ is always sensibly, but very gradually, brighter in the middle. It never has the appearance of nebulous matter, but looks as if it were light reflected from infinitely small particles of dust. In connection with the appearance of this object, and my statement that it is gradually brighter in the middle, I understand that Prof. W. H. Pickering saw it at Arequipa as a large annulus—a ring of light with a dark centre. Besides the changes of form, and its connection with a zodiacal band, I think my observations pretty conclusively show that the ‘Gegenschein’ lags behind exactly opposite the Sun, *i. e.* its longitude is less than 180° greater than the Sun's longitude. For if we take the means of these quantities for the different series of observations which I have published, we have:—

“From 1883 to 1887, $\lambda-\odot=179{\cdot}4$ ...... 16 observations.
From 1888 to 1891, $\lambda-\odot=179{\cdot}4$ ...... 16 „
Sept. and Oct., 1893, $\lambda-\odot=179{\cdot}6$ ...... 22 „

“It is just possible that this peculiarity is due to atmospheric absorption, as the majority of the observations have been made to the east of the meridian, where the absorption of the air would have a tendency to make the centre of brightness less in longitude than it really was.

“As I have previously said, my observations do not seem to show any decided parallax to the object. If its distance was less than half that of the Moon, its displacement would be detected in the observations.

“Still the query if it may not be an atmospheric phenomenon—some sort of abnormal refraction—is yet a legitimate one, though absence of parallax is fatal to it.

“These observations support and confirm the fact that the ‘Gegenschein’ has always a north latitude, as shown by the following:—

“From 1883 to 1887, $\beta=+0^\circ{\cdot}4$ ...... 16 observations.
From 1888 to 1891, $\beta=+1{\cdot}3$ ...... 16 „
In 1893, $\beta=+0{\cdot}5$ ...... 22 „

“The observations of Prof. Baily, when published by Prof. E. C.

Pickering, will doubtless remove any ambiguity in this, and show whether the observed north latitude is not due to atmospheric absorption. If this is shown to be the case, then the lagging of the longitude of the 'Gegenschein' from $\lambda - \odot = 180^\circ$ will be explained in the same manner."

Then follow the notes of each night, from which we extract the following as a specimen of the kind of observation:—

> "Oct. 4. Very large and dense. Sky clear. It is 20° in diameter, sensibly elongated. There is a zodiacal band from it east and west. The 'Gegenschein' is very dense, and could scarcely be missed by anyone looking only casually in its direction."

"In conclusion, I would say that I believe the latitude of the 'Gegenschein,' and the lagging in longitude, are due to atmospheric absorption, and that the object is exactly opposite the Sun, and that it lies in the ecliptic, and if its centre were a definite point the position of the Sun could be accurately determined from observations of the 'Gegenschein,' by changing the sign of the declination, and subtracting 12 hours from the Right Ascension."

Selenographical Notes.

SCHILLER AND THE NEIGHBOURHOOD.—The area which includes this ring-plain and its companion Bayer, and the region between Phocylides and Segner on the east, presents many points of interest and peculiarities of structure which may be advantageously observed under a low morning Sun, or about the time when the west wall of the latter formation is on the terminator. But for foreshortening, Schiller would appear as a very irregular rhomboidal-shaped formation with nearly straight sides. Its border is apparently continuous, being only broken at one place on the west by a large shallow crater, a little below the crest of the wall. A long winding forked ridge, or rather mountain-range (for, judging by its shadow, it is at least as high as the lofty west wall), runs from a depression between Bayer and Schiller in a north-westerly direction, and is evidently associated structurally with the latter. A lower ridge proceeding from the northern section of the border joins this and forms a large enclosure, which is prominently shown by Schmidt. At the outer foot of the southern section of the eastern wall is a number of large depressions which are very strikingly displayed at this phase. They are apparently without rims, and the most southerly of the group forms the largest member of a crater-row extending for some distance across the plain nearly at right angles with the direction of the other objects. Neither Schmidt or Neison show these.

The floor of Schiller, except on the north, appears to be very level and devoid of detail. On April 10, 1881, $7^h\ 45^m$ to 9^h, I detected a craterlet thereon, nearly central, and at 8h 30m, 1893, March 28, I saw this and another, just clear of the shadow of the western wall, more to the north. Neison shows neither of these objects. Schmidt has three, the most southerly of which answers apparently to that which I observed on the two nights just specified. The axial ridge on the northern quarter of the interior is a very conspicuous feature, and is prominently drawn by Schröter, Sel. Top. tab. 47.

Bayer is an interesting object under a somewhat higher angle of illumination, *i. e.* when the interior is nearly free from shadow. There is one crater near the centre of the floor, an easy feature, and three others at the inner foot of the east wall, only one of which is shown by Neison, and none of them by Schmidt.

Between 8h 30m and 9h 45m on March 28 this year, the region east of Schiller was remarkably well placed for observation, and presented a beautiful picture with a power of 284. A very wide valley, bounded on either side by lofty mountains and by the borders of some unnamed formations, extends from the southern side of the ring-plain and curves round to the western flank of Segner, where it terminates. This very conspicuous object cannot be traced in the maps, all of which appear to be very faulty in the representation of this district. It is worth looking at, as we may search in vain for anything quite like it elsewhere. The Rheita and Reichenbach valleys, near the south-western limb, bear perhaps the nearest resemblance to it. The barren region east of Schiller is crossed by "a fault" very similar and nearly parallel to the well-known object of the same class in the neighbouring Phocylides.

LUNAR PHOTOGRAPHY.—In an article in the current number of the 'Observatory,' Mr. Williams charges me with underestimating "the value of lunar photography in its present state of perfection." He surely cannot have seen what I have written both in this Journal and elsewhere on the subject, or he would not do this. I believe it was in these pages that attention was first drawn by me to the very remarkable details brought to light by Dr. Weinek's enlargements of the Lick photographs, and from time to time the hardly less valuable work done at the Paris Observatory has also been referred to here at some length. If, in the course of my remarks, I have occasionally ventured to suggest the desirability of exercising a little philosophical caution before accepting as actual lunar structure *everything* displayed in these very beautiful pictures, it must not be attributed to any lack of appreciation of the valuable labours of those engaged in a work so helpful to direct observation, and which promises to do so much for Selenography.

Beaumont House, Shakespeare Road,
Bedford, 1893, Dec. 19.

THOS. GWYN ELGER.

ERRATUM.—Page 412 (vol. xvi.), line 16 from bottom, *for* Lupus *read* Zupus.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Nomenclature of the Satellites of Jupiter.

GENTLEMEN,—

Mr. W. T. Lynn has omitted to notice that the same objection exists to the renewed adoption of Callisto as a name of the fourth satellite of Jupiter that applies to the adoption of Io and Europa as names of the first and second satellites. For Callisto is the name of the minor planet No. 204, discovered in 1879 by Palisa. On looking through the list of minor planets their names will be found to be universally feminine, Athor (No. 161), a child of Ra, being identified with Aphrodite. A pretty large choice of names may be made from the sons of Jupiter, thus:—Epaphos, son of Io; Minos, Rhadamanthys, and Sarpedon, sons of Europa; Arcas, son of Callisto; Amphion and Zethos, sons of Antiope; Dionysus of Semele; Perseus of Danae; Hercules of Alcmena. The last two, however, are already attached to constellations.

For my part, I should prefer to retain the Roman numerals, I., II., III., IV., as approved by long usage, and brief in writing, but possibly the new satellite might be denoted by the letter B, the initial of its discoverer's name. This would leave A for a possible discovery by the Yerkes telescope of a satellite still nearer Jupiter, and if ever a further small satellite should be found between III. and IV., analogous to Hyperion between Titan and Iapetus in the system of Saturn, such addition to the system of Jupiter could be denoted by the letter C. We should thus have a system of denomination which would show the order of distance of the possible small satellites of the future, and at the same time preserve the very convenient numeration of the Galilean satellites.

Murston Rectory, Sittingbourne,
1893, Dec. 18.

Yours faithfully,
A. FREEMAN.

The Comet of A.D. 524.

GENTLEMEN,—

It is not often that the recorded appearance of a comet helps us to fix a doubtful historical date, but it seems to me that that of the above comet does.

Cedrenus tells us that a comet was visible during twenty-six days in the seventh year of the reign of the Emperor Justin I., who succeeded Anastasius I. in A.D. 518, so that the comet probably appeared in A.D. 524. He also speaks of another comet, seen five years before, which had a tail turned towards the west, as it is also described by Theophanes. These are catalogued by Pingré and others. But I cannot find any reference in modern authors (except in Mr. Hodgkin's history of Theodoric) to the account given in the anonymous fragment which is usually printed at the end of the chronicles of Ammianus Marcellinus. Many prodigies, the writer tells us, occurred at the time when the mind of Theodoric became suspicious, which led him to give heed to the accusations of Cyprian against Boethius, the most eminent of his subjects, and resulted in the murder of the latter and afterwards of his father-in-law, Symmachus. One of these was the appearance of a comet thus related:—"Stellâ cum faculâ apparuit, quæ dicitur cometes, splendens per dies XV., et terræ motus frequenter fuerunt." There can be but little doubt that this was the same as that mentioned by Cedrenus, who also speaks of earthquakes taking place about the time of its appearance. Now the execution of Boethius was preceded by a long imprisonment, during which he wrote his famous treatise, 'De Consolatione Philosophiæ.' It would seem, therefore, that his death must have taken place in A.D. 525, one year before that of Symmachus, which was shortly followed by the remorse and death of Theodoric. I am sorry to differ from Mr. Hodgkin, who places the death of Boethius in A.D. 524, but the above argument appears to be strong.

Yours faithfully,

Blackheath, 1893, Dec. 8. W. T. LYNN.

Bayer's Nomenclature.

GENTLEMEN,—

As no one seems to have discussed Mr. Lynn's paper ('Observatory,' Sept. 1893, p. 313), I offer the following remarks upon it.

I agree with Mr. Lynn that it is a pity Bayer did not more strictly follow whatever rule he may have selected in carrying out the lettering of the stars; not that he should have followed the magnitudes more carefully, but that he might have followed the positions more closely. For instance, in Pegasus, why did he not letter λ and μ before ι and κ? In Taurus, ϕ and χ seem to be transposed. In Aquila, including Antinous (which I suppose he must have considered the principal figure of the combined constellation) there seems to be considerable confusion of order. There are no doubt other instances of departure from his rule, which, I believe it is understood, was to take all the stars in a constellation of a given magnitude and letter them in order from the head of the figure to the tail (or to the foot); then take the stars of the nearest magnitude; and so on.

It is much easier to remember the names of the stars when they are arranged in the order of position than in that of magnitude. I presume Bayer must have had a catalogue upon which he based his names, but that this catalogue only contained magnitudes to whole numbers; if this were so, it was obviously impossible for him to arrange the stars strictly in the order of magnitude. Of course if a more exact catalogue had existed then, it would have been very useful now.

As regards the best nomenclature for the future, would it not be best to keep, as a general rule, to Heis's interpretation of Bayer for the northern hemisphere, and to Gould's for the southern—making as few exceptions as possible? In the maps I contemplate publishing (though the necessary preparation for them is not yet completed), it is proposed to discard those Roman letters which might easily be mistaken for other letters, such as Q, e, i, k, l, o, p, s, v, w, x, z. The question has also been raised whether in cases where the same Greek (or Roman) letter is used to designate more than one star in a constellation, that letter should be dropped, and Flamsteed's No. used instead—at any rate, in cases where there are differences of identification by various authorities, as with the π's in Orion. T. W. BACKHOUSE.

Sunderland, 1893, Dec. 22.

OBSERVATORIES.

[Continued from vol. xvi. p. 420.]

KALOCSA. *J. Fényi.*—Observations of the Sun were continued as in former years. The Sun's limb was completely examined on 163 days and partially so on 36 days. M. Fényi mentions that on May 5 and October 3 the protuberances extended 8′ 51″ from the limb. Drawings of the Sun were made on 232 days and 245 detailed drawings of certain portions were also executed. Variable stars; meteorological observations.

KARLSRUHE. *W. Valentiner.*—The transit-circle has been used for observations of the limbs of the Moon and of Mösting A, 71 pole stars, and 533 catalogue stars. Observations for personal equation. With the 6-inch refractor places were obtained for comets Swift, Brooks I., Winnecke, Holmes, and Brooks II. With the Bamberg transit a large number of observations were made of groups of pairs of stars (winter, spring, summer, and autumn groups). Time service.

KIEL. *A. Krueger.*—"Die Centralstelle für astronomische Telegramme." Herr Lamp made a number of observations in the prime vertical with a portable transit.

KÖNIGSBERG. *C. F. W. Peters.*—Zone-observations north dec. 83° and 84°, down to the 9th magnitude. Measures of Σ 1321 for annual parallax. Positions of cusps in the lunar eclipse of May 11 by Prof. Franz. Measures of a few wide doubles. Heliometer measures of Pleiades, and of comets 1892 I. (Swift), Holmes, 1892 VI. (Brooks).

"Seitens der Königlichen Akademie der Wissenschaften in Berlin wurde Prof. Franz eine Summe von 3200 Mk. auf seinen Antrag bewilligt, um dafür einen grösseren Coordinaten-Messapparat zum Ausmessen der uns von der Licksternwarte übersandten, mit den 36-Zöller aufgenommenen Mondphotogramme zu beschaffen. Der Apparat ist bei den Herren Repsold in Hamburg in Bestellung gegeben und seine Fertigstellung steht gegen Ostern d. J. in Aussicht."

KREMSMÜNSTER. *C. Wagner.*—Observations with the 6-inch refractor of comets 1891 II. (Wolf), 1892 I. (Swift), Denning, Brooks I. and II., Winnecke, Holmes. Sun-spot observations on 203 days. Magnetic and meteorological observations.

LEIPZIG. *H. Bruns.*—The parallax measures with the heliometer were continued. The observations of Br. 3077 (3 years), Arg.-Oeltzen 10603 ($2\frac{1}{2}$ years), and μ Cassiopeiæ (2 years) have been completed and a new set for Lalande 15290, 18115 (both components), and ϕ Ursæ Majoris begun. Dr. Hayn has commenced regular work with the refractor on a working list for the zone +10° to 15°, containing about 400 doubles and 500 other objects. Dr. Hartmann is making observations for latitude with the Universal Instrument. Time service. Weather reports.

LUND. *A. Möller.*—The 4th volume of the zone-observations is almost complete.

MILAN. *G. Schiaparelli.*—Some 545 measures of double stars were made with the 18-inch refractor. The observations of Mars have been very unsatisfactory, owing to bad definition and the southern declination of the planet. The 8-inch refractor has been used by Prof. Celoria both for measures of double stars and for observations of Mars. He also obtained places for comets Swift, Denning, and Winnecke. Magnetic and meteorological observations. Time service.

MÜNCHEN. *H. Seeliger.*—Estimates of screw-errors of new 6-inch transit-circle.

Herr Oertel made a series of measures of Saturn and the ring-system with the $10\frac{1}{2}$-inch refractor, and obtained places for Comet Winnecke. Photometric measures. Meteorological observations.

O'GYALLA (UNGARN). *Konkoly.*—The work of the Observatory during 1892 was of necessity reduced to a minimum, on account of the time devoted to the organization "des telegraphischen Wetterprognosendienstes." However, "die Sonnenfleckenbeobachtungen, sowie die Sonnenfleckenzählungen, sowie auch die Sternschnuppenbeobachtungen" were continued when the weather permitted. On none of the 156 observing-days was the Sun free from spots. Spectroscopic observations of Nova Aurigæ, Comet Swift,—"Am 2 April, $15^h\ 30^m$, habe ich weitere Messungen mit einem grossen Spectroskop angestellt und die Position der 5 Linien wie folgt gefunden: $\mu\mu = 558{\cdot}40$; $543{\cdot}80$; $516{\cdot}26$; $472{\cdot}7$ und $468{\cdot}10$. Die Helligkeiten schätze ich auf: 0·5; 0·3; 1·0; 0·2 und 0·1, wenn die Zählung am rothen Ende begonnen wird. Das continuirliche Spectrum erstreckte sich von Wellenlänge 559 bis 449 $\mu\mu$,"—γ Cassiopeiæ, Comet Holmes (continuous), β Orion.

POTSDAM. *H. C. Vogel.*—A small spectrograph and euryscope have been fitted on the 13-inch astrographic telescope. With this spectrograph and the old one in combination with the large refractor, a number of spectra of the large planets, the two brightest of Jupiter's satellites, and some interesting stars (β Lyræ) have been taken. Prof. Scheiner, with the large spectrograph, has been employed in determining motion of stars in the line of sight. Dr. Lohse has made 49 measures of position of the polar spot on Mars. With the newer elements Dr. Lohse has computed the following comparison of old and new observations of the position of the south polar cap:—

Jahr.	Areogr. Länge. °	Polabstand. °	Beobachter.
1783	4·31	5·53	Herschel.
1798	17·29	1·05	Schroeter.
1830	23·74	7·26	Bessel.
1862	4·46	5·08	Kaiser.
1877	26·49	5·32	Hall.
1877	29·47	6·15	Schiaparelli.
1879	48·08	4·97	Schiaparelli.
1892	23·23	5·71	Lohse.

In consequence of the work on the star chart not being definitely begun, the 13-inch was free for observations of objects of special interest. Prof. Scheiner obtained good plates of the Orion Nebula to be used in a systematic measurement of this object, also of the nebula near ξ Persei and the Andromeda Nebula. The researches of Prof. Scheiner on the cluster of Hercules (Messier 13) have already appeared in Proceedings of the Berlin Royal Academy. Dr. Wilsing has taken photographs for parallax determination of 61 Cygni as well as a number of other photographs.

The observations for the first part of the photometric Durchmusterung, embracing 3522 stars in the zone 0° and +20°, are concluded, and the reduction has been pushed on, so that the printing has begun. In 1892 Dr. Lohse took 135 photographs of the Sun of 10 cm. and 20 cm. diameter.

Prag. *Safarik.*—In his previous report Prof. Safarik complained that 1891 was the most unfavourable for observation since 1875, he having had but 96 observing days. The report for 1892 is more favourable, as he could observe on 136 days. The observation of the lunar eclipse May 11 was good, and many occultations noted. Numerous observations of Mars. Some 1700 estimations of magnitudes of 140 variable stars were made. Prof. Safarik intends to drop these observations for a time, that he may be free to reduce his whole series of 20,000.

[To be continued.]

Royal Alfred Observatory.—We have just received the "Annual Report of the Director of the Royal Alfred Observatory, Mauritius, for 1891." Besides the Director (Mr. C. Meldrum) the staff consists of Mr. Bell (first Assistant) and four others. The ordinary work consists of the usual meteorological observations, storm-warnings, collection and reduction of observations made at sea, magnetic observations, and photographs of the Sun. Concerning the latter we learn that in 1891 the observatory forwarded to the Solar Physics Committee 369 negatives and 342 silver prints. The following Table is abstracted from the report, as containing interesting information in various directions:—

Years.	Number of days on which spots were seen.	Number of days on which no spots were seen.	Number of days of no observation.	No. of groups.	No. of photos.
1876 ..	172	175	19	20	93
7 ..	180	168	17	50	115
8 ..	61	262	42	11	67
1879 ..	103	245	17	26	77
1880 ..	287	55	24	98	330
1 ..	326	7	32	168	370
2 ..	337	2	26	175	473
3 ..	322	11	32	190	441
4 ..	340	0	26	192	477
5 ..	324	8	33	162	484
6 ..	278	75	12	74	533
7 ..	236	116	13	64	509
8 ..	194	158	14	42	418
1889 ..	139	205	21	31	440
1890 ..	186	160	19	47	489
1891 ..	334	15	16	170	532

PUBLICATIONS.

The Milky Way [*].—So soon after the publication of Dr. Boeddicker's Atlas, it is satisfactory to note the appearance of an independent series of drawings of the northern Galaxy. M. Easton has enhanced the value of his work by refraining from making any alterations after consulting the drawings of others. The original drawings were copied by the author himself upon grained transfer-paper and printed from stone; he has thus avoided any errors which might be introduced by the intervention of another hand, but a coarseness of grain and uncertainty in printing is unavoidable in this mode of reproduction. It is probably an accident of printing that the first map is much darker and more intense than the second, while the coarseness of execution is especially shown in the General Map, which is on a much smaller scale than the others, and in parts of which even the stars are somewhat obscured.

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[*] 'La Voie Lactée dans l'hémisphère boréal; cinq planches lithographiées, description détailée, catalogue, et notice historique; avec une préface par H. G. van de Sande Bakhuyzen.' Dordrecht et Paris, Gauthier Villars, 1893.

M. Easton gives a detailed description and a catalogue of the spots and luminous streams, with reference to an outline map. He carefully explains that the catalogue is only provisional, and it may be of use for future reference. The work is preceded by historical references to previous drawings, and an appendix gives a translation of Ptolemy's description, from Book VIII. of the 'Almagest.'

As tests of his vision M. Easton gives a list of the stars which he can see or separate with the naked eye. These tests are more to the purpose than might appear at first sight, for while the luminosity of the Milky Way may be mainly caused by great numbers of extremely faint stars, the appearance of many portions is considerably modified by the occurrence of stars close to each other, which are very much nearer the limit of visibility. It is evident that upon the power of an eye to see these *as separate stars*, the character of the delineation will to a great extent depend.

The first three plates give the details of the Milky Way upon a larger scale than plate IV., which is a General Map divided into two sections. This General Map is stated to be the principal drawing: it appears to have been made subsequently to the others, as the positions of the stars on it are laid down from the data published by Mr. Marth, while the detail maps were drawn before the author thought of availing himself of Mr. Marth's work. It is unfortunate that the same projection was not employed throughout, as the maps would have been more easily comparable.

It is a serious defect in the General Map that it is cut off by its side-margins so closely that its extreme boundaries are not shown—a nearly uniform nebulosity reaching in some parts to its edges, where in the detail map the Milky Way has much less extent. On the other hand, the restricted space allowed for the General Map cuts off outlying streams which are given in the detail drawings.

On comparing M. Easton's work with that of Dr. Boeddicker, it is obvious at a glance that the former shows far less detail. The contrast is very striking at the margin of the Milky Way between Cygnus and Andromeda, where M. Easton's drawing ends in an almost straight line, broken up by Dr. Boeddicker into a multiplicity of detail. At the same time, there is perhaps more *general* resemblance between the two drawings in the region between Cygnus and Scutum than in any other portion. Here the great division in the Milky Way is more conspicuous in M. Easton's drawing than in that of Boeddicker, where it is somewhat too much obscured by the detail. It is discouraging to note how little the two drawings have in common in the region between Cygnus and Auriga, where but few of the numerous streams running nearly at right angles with the general axis of the Galaxy, drawn by Boeddicker, appear in M. Easton's drawing. There is rather more accordance in the outlying portion between Taurus and Orion, though here the central parts are very different.

It is quite clear that there is yet far from being a general agreement between drawings made by different observers, and it is much to be desired that others may undertake the very difficult task of delineating independently the naked-eye appearance of the Milky Way. It can only be by the accumulation of independent drawings that personality can be eliminated, and a representation obtained sufficiently certain and satisfactory to be used with confidence in the future discussion of possible changes.

There are several misprints in the work, but the only one which need be specified is in the postscript, where 'Monthly Notices,' Vol. lxxx. should read Vol. liii. W. H. WESLEY.

A NEW edition of Webb's classic work 'Celestial Objects for Common Telescopes'* is always looked forward to with interest in astronomical circles. The fifth edition is now before us, or rather a portion of it, for Mr. Espin has divided it into two volumes, and our duty is to express an opinion on the manner in which so popular a work has been brought up to date. This first volume deals with the telescope, the method of observation, and on the several members of the Solar System. There can be little doubt that Mr. Espin made a good start in securing the services of such specialists as Miss Brown for the Sun, Mr. T. G. Elger for the Moon, Mr. A. Stanley Williams for Venus and Mercury, Rev. W. Waugh for Jupiter, Rev. A. Freeman for Saturn, and Mr. W. F. Denning for Comets. A mere enumeration of the above is a guarantee that the information added is of that order which is demanded by possessors of the original editions, and we are glad to say that faults are extremely difficult to find. There is, however, one point on which we differ from Mr. Espin, viz., the addition of all new matter in the form of footnotes. A footnote is extremely useful, but when everything is a footnote it becomes irksome. This is, of course, a matter of taste to a great extent, but we think the better course would have been to incorporate the new matter with the text, as we understand is to be done in the second volume.

THE TOTAL LUNAR ECLIPSES OF 1884 AND 1888.—It will be remembered that on the occasions of the Total Eclipses of the Moon on 1884 Oct. 4 and 1888 Jan. 28 lists of stars which would be occulted during totality were sent out by Dr. Döllen, of Pulkowa; and by the concerted action of many observers a large number of observations of the disappearances and reappearances of these stars was secured. It was hoped that this mass of material would give a good value of the diameter of the Moon, and the discussion of the observations by Dr. Ludwig Struve * will doubtless be eagerly read by all those interested in exact astronomy. The following is a brief summary of his very able and interesting paper.

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* 'Celestial Objects for Common Telescopes.' By the Rev. T. W. Webb. Fifth edition, revised and greatly enlarged by the Rev. T. E. Espin. Longmans, Green, & Co. Vol. I. Price 6s.

He divides the 116 stars observed in 1888 (after rejecting some observations) into four groups, viz.:

I.	158 observations of	11 stars,	magnitude	6·5 to 9·0.
II.	145 ,,	19 ,,	,,	9·1 to 9·4.
III.	282 ,,	23 ,,	,,	9·5.
IV.	250 ,,	63 ,,	not in DM.	

The places of these stars were obtained by measurement of a photograph taken by the brothers Henry. Putting $\Delta\alpha$ and $\Delta\delta$ for the corrections to the Moon's R.A. and Dec., Δr for the correction to diameter, and $\Delta\pi$ for correction to parallax, the following values for these quantities are found from the different groups:—

Group.	$\Delta\alpha$. ″	$\Delta\delta$. ″	Δr. ″	$\Delta\pi$. ″
I.	+1·73	+1·47	−0·09	−0·04
II.	+1·54	+1·60	+0·51	−0·04
III.	+1·44	+0·62	+0·53	−0·39
IV.	+1·19	+0·55	+1·12	−1·69

The progressive change in all these quantities is striking, and points to some systematic error depending on the brightness of the star. Dr. Struve decides, however, that the suggested corrections to the parallax have no real meaning—in which decision he is supported by the magnitude of the probable error for these corrections as found from the equations, viz. 0″·2 or 0″·3. He therefore solves the equations again, omitting the correction for parallax, or rather transferring it to the other side of the equations as a quantity which the observations are not suited to determine. He then finds:—

Group.	$\Delta\alpha$. ″	$\Delta\delta$. ″	Δr. ″
I.	+1·73	+1·49	−0·10
II.	+1·54	+1·61	+0·50
III.	+1·40	+0·80	+0·44
IV.	+0·97	+1·28	+0·59

The progressive change is now not so marked, but the correction to diameter indicated by Group I. is quite different from that indicated by the other three groups, and suggests that the illu-

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* 'Bearbeitung der während der totalen Mondfinsternisse 1884 Oct. 4 und 1888 Jan. 28 beobachteten Sternbedeckungen durch Dr. Ludwig Struve.' C. Mattiesen, Dorpat, 1893.

mination of the Moon, which was fairly bright even at mid-totality, influenced the observations of the fainter stars.

Dr. Struve proceeds to subdivide the stars of Group I. into two smaller groups, viz. stars mag. 6·5 to 8·0 and 8·1 to 9·0, and finds

$$\Delta r = -0''\cdot 14 \quad \text{and} \quad \Delta r = -0''\cdot 05$$

respectively, so that the progressive change in Δr according to the brightness of the star occulted still holds. He then re-examines the observations of 1884 Oct. 4 from this point of view. He had previously taken all the stars together, but he now divides them into 3 groups (there were not so many observations in 1884 as in 1888), and finds from these three groups

From stars mag. 6·0 to 9·4 ...... $\Delta r = +0''\cdot 26$
" " 9·5 .... $\Delta r = +0\ \cdot 08$
" not in DM........... $\Delta r = +0\ \cdot 16$

Here, then, the progressive change is not reproduced, which Dr. Struve attributes to the fact that the residual illumination of the Moon was much less in 1884 than in 1888. He is therefore inclined to think that the occultations of faint stars in 1888 are affected with systematic error, and to retain only the first group for association with the observations of 1884 in determining the correction to diameter, the definitive result for which he gives as

$$\Delta r = +0''\cdot 125$$

or

$$r = 15'\ 32''\cdot 645 \pm 0''\cdot 044,$$

though he rightly remarks that, in view of the existence of the above systematic error, the smallness of the probable error $\pm 0''\cdot 044$ is misleading.

Those who assisted in the work will doubtless be much interested in inspecting the residuals which Dr. Struve so carefully tabulates for the individual observations. We congratulate him on the completion of an admirable piece of work, though he must feel somewhat disappointed at finding once more that the accuracy of astronomical observation is limited by hitherto unsuspected causes of error.

BULLETIN OF THE ASTROGRAPHIC CHART, VOL. II. PART 2.—This part opens with a reference to the death of Admiral Mouchez and the election of M. Tisserand as President of the Permanent Committee. Then follows a memoir by M. Kapteyn (which has already been referred to in these columns) on the systematic differences between visual and photographic magnitudes. M. Kapteyn's principal conclusion is important enough to merit literal reproduction once more :—" La lumière des étoiles dans la voie lactée, ou dans son voisinage, est plus riche en rayons actiniques que la lumière des étoiles du même type spectral situées dans les latitudes galactiques considérables." Three valuable memoirs by M. Loewy and one by the brothers Henry on methods of reduction of measures on stellar photographs complete that part of the fascicule devoted to scientific memoirs. The question of the reduction of stellar measures is too large a one to deal with in this brief note, and has recently formed the subject of several articles in this magazine. But the memoirs are followed by an admirable summary of the correspondence with which M. Tisserand has had to deal since his election, which is worthy of careful attention. The different directors of observatories have reported their difficulties with the réseau, the film of which corrodes quickly into pinholes; some wish to reject the réseau, others suggest a varnish to preserve it. We are inclined to think the réseau far too valuable to be rejected. The false stars can always be detected, if in no other way, by their occurrence on many photographs. Questions are asked again about the ground edges of the plates, and about the necessity of taking a "cliché-type" every night (the brothers Henry say this is far too often—types at intervals of some weeks are quite sufficient); about developers, about measures, &c., &c. In fact this correspondence reminds us once more that all the meetings of the Committee were held, and their resolutions made, before the work was begun, and consequently a good deal in the dark. Many of the resolutions might now be re-discussed with the advantage of experience, and we hope that M. Tisserand will soon see his way to another meeting of the Committee. There seems some danger that uniformity in the work may be gradually lost unless some of the doubtful points are again submitted for decision to the Committee.

CONTRIBUTION TO THE STUDY OF SATURN'S RINGS BY MDLLE. KLUMPKE.—We heartily congratulate Mdlle. Dorothea Klumpke, the Directrix of the 'Bureau des Mesures,' in Paris, on obtaining the grade of "Docteur ès Sciences Mathématiques." Mdlle. Klumpke has chosen as the subject of her thesis the form of a meridian section of one of Saturn's rings, which is supposed to consist of fluid material, or at least of solid material surrounded by a liquid film, and to be maintained in equilibrium by the attraction of its molecules combined with a rotatory movement. This problem is purely hypothetical, and is not in accordance with the theories respecting the nature of Saturn's belts held at the present day. It was originally treated by Laplace, and later by Mdme. Kowalewski and M. Tisserand. Mdme. Kowalewski supposed the ring to be generated by a plane curve which turned round an axis passing through the centre of Saturn and perpendicular to the plane of the curve's motion. The differential equation for equilibrium of the ring is easily seen to be

$$fV+\frac{fM}{\sqrt{\xi^2+\eta^2}}+\tfrac{1}{2}\omega^2\eta=c.$$

Where ξ, η are the coordinates of any point on the generating curve, referred to rectangular axes through Saturn's centre; σlx,

σly the coordinates of the same point referred to parallel axes through the centre of the curve; V the potential due to the ring's attraction; M the mass of Saturn; ω the angular velocity of the ring; l the distance between the centre of Saturn and the generating curve; and f the force of attraction; ρ the density of the ring supposed homogeneous.

To evaluate V, Mdme. Kowalewski made use of Gauss's formula $V=\frac{1}{2}\rho\int\cos i d\Sigma$, which, in the present case, reduces to the form

$$\pm V=2\rho l^2\int_0^{2\pi}dt\int_0^{\frac{\pi}{2}}\frac{\sigma^2(x-x_1)\frac{dy}{dt}-\sigma^2(y-y_1)\frac{dx}{dt}-2\sigma(1+\sigma y_1)\frac{dx}{dt}\cos^2\theta}{\sqrt{\sigma^2(x-x_1)^2+\sigma^2(y-y_1)^2+4(1+\sigma y)(1+\sigma y_1)\cos^2\theta}}(1+\sigma y)d\theta.$$

Mdme. Kowalewski now expresses x and y in terms of a parameter t, assuming

$$y=-\cos t$$
$$x=a\sin t+a'\sin 2t+a''\sin 3t. \; . \; . \; .$$

but limits the series for x by taking

$$a''=a'''= \; . \; . \; . \; =0,$$

and $a'=\sigma\gamma'$, where γ is a finite quantity.

The resultant curve is found to be

$$\xi=\sigma l(a\sin t+\sigma\gamma'\sin 2t),$$
$$\eta=l(1-\sigma\cos t).$$

In her thesis Mdlle. Klumpke undertakes the task of finding what modifications in the form of this curve follow on the retention of the term $a''\sin 3t$, still assuming that

$$a'''=a^{\text{iv}}= \; . \; . \; . \; =0,$$

and that $a'=\gamma'\sigma$; $a''=\gamma''\sigma^2$.

The succeeding pages are occupied with the evaluation of the very complicated integrals which result from the retention of this term, even though all powers of σ higher than the 4th are neglected. Neglecting all values of σ higher than σ^2 as a first approximation, Mdlle. Klumpke deduces the following numerical values of the constants :—

$$a=+0{\cdot}385$$
$$\gamma'=-0{\cdot}188$$
$$\gamma''=-0{\cdot}109,$$

taking

$$\frac{\omega^2}{\pi f l}=\frac{M}{\pi\rho l^3}=0{\cdot}216,$$

$$c=\frac{M}{l}+\frac{\omega^2 l^2}{2f}.$$

In the second part of the thesis the comparatively simple case is taken of the value $M=0$. A third approximation gives for the coordinates of a point on the generating curve the values

$$\xi=\sigma l(1-h\sigma^2)\sin t+\frac{hl}{8}\sigma^4\sin 2t,$$
$$\eta=l(1-\sigma\cos t),$$

where $h=\frac{1-a}{\sigma^2}$. Neglecting the third term in the development of ξ we get an ellipse whose semi-axes are

$$\sigma l(1-h\sigma^2) \quad\text{and}\quad \sigma l.$$

The small term $\frac{hl\sigma^4}{8}\sin 2t$ introduces a series of undulations in this ellipse which are especially marked at points where

$$t=0,\ \frac{\pi}{2},\ \pi,\ \frac{3\pi}{2}.$$

In comparing Mdlle. Klumpke's results with those of Mdme. Kowalewski we see that the retention of $a''\sin 3t$ affects the values of ξ and η to a very slight degree. The effect of $a'''\sin 4t$ and all succeeding terms would be almost inappreciable. A. S. D. R.

IN THE HIGH HEAVENS *.—To take a sentence from the book now before us—"There is a large and ever increasing class who are anxious for general knowledge with regard to the physical phenomena of the globe," and, we may add, of those of other bodies of the celestial universe. Sir R. Ball's latest work, 'In the High Heavens,' is obviously designed to meet the wants of this class, and well fulfils its purpose. The book consists of essays, some of which have already appeared in the monthly reviews, on various occasional phenomena which have aroused some public interest during the last few years; thus we have chapters on "The Eclipse of April 1893," "The Fifth Satellite of Jupiter," "Mars," "The Heat Wave of 1892," and the "Wanderings of the North Pole." In this last-mentioned chapter we are inclined to think that the variation of position of the terrestrial pole, which is as yet scarcely accepted as a veritable fact, is stated as such with too much definiteness. No doubt the evidence for this variation is strong, but we think that Mr. Chandler himself would say that as yet it is not to be accepted with the same amount of confidence as we have in the existence of the Precession of the Equinoxes. Appearing as it does in this book, it will be taken as a real fact of nature, which will be hard to eradicate from the popular mind if it prove to be an error. However, this criticism does not apply throughout the book; the other chapters consist of statements of facts written in a charmingly lucid manner, with whatever con-

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* 'In the High Heavens.' By Sir Robert S. Ball, LL.D., F.R.S. Isbister & Co., London. Price 7*s*. 6*d*.

clusions are drawn from them carefully reasoned out, and exhibited with the well-chosen illustrations that Sir Robert Ball always has at his command.

The book is a handsome and well-printed volume, quite suitable for presentation.

NOTES.

Comet Notes.—Brooks' Comet *c* 1893 is rapidly growing fainter, but from its high north declination it will probably be followed for some time longer. The following is an ephemeris for Berlin midnight:—

	R.A.			N. Decl.			R.A.			N. Decl.	
1894.	h	m	s	°	'	1894.	h	m	s	°	'
Jan. 1	20	6	34	75	13	Jan. 17	22	51	8	68	27
5	21	4	31	74	0	21	23	12	10	66	36
9	21	49	36	72	18	25	23	29	40	64	52
13	22	24	8	70	24	29	23	44	38	63	14

A. C. D. C.

Minor Planet Notes.—Only one new planet (AP) has been discovered in the last month; it was found by M. Charlois on Dec. 6. Planet 1893 L, which was recently numbered (359), turns out to be identical with (89) Julia; an error in the 'Berliner Jahrbuch,' combined with the unexpected brightness of the object, prevented its identity being detected earlier.

Dr. Berberich has deduced new elements of (175) Andromache, which was rediscovered this year; the aphelion distance was previously given as 4·70 (the greatest of the whole family), but it is now reduced to 3·87. (334), discovered by Wolf on Aug. 23, 1892, has been named Chicago, and (344), discovered by Charlois, Nov. 15, 1892, has been named Desiderata. A. C. D. C.

Periodical Comets.—Mr. Lynn writes to call attention to the fact that not one of the known periodical comets is due to return to perihelion during the present year. Encke's was last in that position on the 18th of October, 1891, so that the next perihelion passage will be due on the 10th of February, 1895.

The comet formerly known as Tempel's second periodical comet was discovered on the 3rd of July, 1873, calculated to be moving in an elliptic orbit with a period of about 5½ years, and was observed at a return in the autumn of 1878, but has not since been seen. Had it returned regularly, appearances would have been due in the winter of 1883, in the early part of 1889, and again in 1894.

A WOLSINGHAM Observatory Circular of Dec. 14 informs us that photographs taken with the Compton telescope show that Es.-Birm. 57 R.A. $11^h\ 39^m\ 58^s$, Decl. $+56^\circ\ 23'$ (1855), Mag. 9·5, is variable. The star is now 8·5 Mag. Type III.

DEATH OF DR. RUDOLF WOLF.—Astronomy has lost an earnest devotee by the death of Dr. Wolf, Director of the Zurich Observatory, who died on December 6 last, at the age of 77 years. Dr. Wolf was born in 1816 near Zurich, and his early studies were under the direction of Horner, Encke, and Poggendorf. In 1847 he was appointed Director of the Observatory at Berne, where he commenced his studies and observations of sun-spots, which studies led him to announce the connection between sun-spots and the Earth's magnetism. In 1855 he was appointed to the new observatory at Zurich, which position he held at the time of his death. Dr. Wolf will probably be chiefly remembered for his work on Sun-spots, in which he has been engaged for almost the last fifty years. His "Sun-spot Numbers," published annually, which give the state of the solar energy for each month in the year, as indicated by the total area of the spots on the Sun for each month in the year, have been of the greatest service to many investigators in this branch of science. As a member of the Federal Geodetic Commission, of which he was formerly President, Dr. Wolf showed an extensive knowledge of Geodesy, and contributed 'A History of Geodetic Measures in Switzerland' to its literature. Among his other works are a 'History of Astronomy,' which is a most valuable work of its kind, and a Treatise on Astronomy,' which is his latest work. Dr. Hirsch, Secretary of the Geodetic Association, thus writes of him:—

"During his long life, wholly devoted to science and filled with sustained and fruitful work, our friend preserved to the last days of his short illness the serene tranquillity which marked his lovable character. His fine figure will remain engraven in the memory of his friends and colleagues as the very type of an indefatigable and powerful worker in the great field of science."

WE regret also to have to record the death of Dr. Adolphe Steinheil, chief of the optical firm of Steinheil & Sons, Munich, who died November 4, 1893, aged 61. Also of Friedrich Gustav von Bülow, who was the founder of the Observatory at Bothkamp, from which MM. Vogel and Lohse issued the three volumes of the Bothkamp observations, 1870–74.

THE new year brings other changes in the Greenwich staff besides that due to the recent appointment of Mr. Turner to Oxford. On Dec. 31 Mr. William Ellis retired from the Royal Observatory after a term of service which must be almost unparalleled. Mr. Ellis entered the Observatory in the year 1841, and has thus, allowing for a period in 1852–53 when he was in charge of Durham University Observatory, completed 51 years' service. In the earlier part of his career Mr. Ellis was occupied in the astronomical branch, and was in charge of the time and chronometer department. During this period he assisted in many longitude determinations, notably that of Alexandria, and afforded much help to the then Astronomer Royal, Sir G. B. Airy, in his magnetic and other scientific investigations.

In 1875 he was chosen to succeed Mr. Glaisher as Superintendent of the Magnetical and Meteorological Department, which post he has filled until his retirement. His activity in these sciences is well shown by numerous papers to the Royal Meteorological and Royal Societies. His papers communicated to the latter on "The Relation between Magnetic Diurnal Range and the Period of Sun-spot frequency" and the "Simultaneity of Magnetic Variations at different places" are especially regarded as valuable contributions to science.

THE second Ordinary Meeting of the current Session of the British Astronomical Association was held on Dec. 27th, in the Mathematical Theatre, University College, Gower Street, Dr. A. M. W. Downing, President, in the Chair.

Nineteen new Members were elected, and fifteen Candidates for election were proposed.

Reports of the Star Colour and Solar Sections were presented. The former drew forth some discussion on the use of colorimeters in the determination of the colours of stars, in which Messrs. Chambers, Holmes, Maunder, and Nelson took part. In the conversation which followed the presentation of the Solar Report, Mr. Holmes described a simple method which he had employed for securing photographs of Sun-spots, and Mr. Maunder in reply to Capt. Noble stated that Auroræ had not been nearly so conspicuous during last winter as in the previous one, though the solar activity was much greater. Miss Everett, as Secretary, read portions of an article on "Jeremiah Horrox," by Dr. Orchard, and Mr. Maunder gave a summary of a paper on the "Distribution of Stellar Types in Space," by Mr. Maclair Boraston. A paper by the Rev. W. R. Waugh, forming an interim report of the Jupiter Section, was also read and gave rise to some discussion. The Meeting adjourned at 6.35.

SOME letters recently appeared in 'Nature' on the simultaneity between solar outbursts and variations of terrestrial magnetism. Mr. Ellis started the correspondence, protesting against the undue importance given in some works on Astronomy to the coincidence between Carrington and Hodgson's observation of a solar outburst on Sept. 1, 1859, and a disturbance of the magnets at Kew, which, there is good reason for saying, was in no sense a large one. Mr. Ellis sums up the matter thus:—

"(1) The solar outburst was seen by two observers; the fact of its occurrence is therefore undoubted.

"(2) The corresponding magnetic movement was small.

"(3) Many greater magnetic movements have since occurred.

"(4) No corresponding solar manifestation has been again seen, although the Sun has since been so closely watched.

"The solar outburst of 1859 would thus appear to have been a rare phenomenon, and its observed occurrence at the time of a recorded magnetic movement quite an accidental occurrence.

"This conclusion in no way invalidates the question of general relation between sun-spots and magnetism, whatever may be the true explanation of that relation."

Other correspondents point out that since 1859 one or two similar solar outbursts have been seen more or less coincident with terrestrial magnetic phenomena, but the main point made of the 1859 phenomenon is that the outburst and disturbance were absolutely coincident. And Mr. Ellis pertinently remarks in one of his letters—"If the smaller magnetic motions do really directly depend on solar changes of so marked a character, how does it happen that many greater recorded magnetic movements remain without corresponding solar changes having been seen?"

DR. A. AUWERS has published, in 'Ast. Nach.' No. 3195–96, the results of an exhaustive piece of work in the way of comparison of star-catalogues. He has compared the fundamental catalogue used in forming the 'Astronomische Gesellschaft' catalogues with forty-seven different others. The result occupies many pages of figures, and it is difficult to comment. The paper should be studied by those interested in star-catalogues.

MR. MARTH writes to us that he is preparing as usual the Ephemeris of Saturn's satellites, but is obliged to use the old elements, as no results of new measures are forthcoming. May we call the attention of observers, amateur and professional, to this want of accurate measures of these satellites? Here is a useful field of work open to anyone who has a large equatorial, with a good micrometer and driving-clock, at his disposal. Mr. Marth would no doubt gladly welcome such measures and use them at an early date.

IN presenting the volume of the *Connaissance des Temps* for 1896 to the French Academy, M. Faye gave details of some additions which have been made to this ephemeris.

(1) Constants for reducing the rectilinear coordinates of the Sun from the mean equinox of the current year to that of the year 1900 have been added for every other day.

(2) In the ephemerides of fundamental stars, the magnitudes, mean places for the beginning of the tropical year, the proper motions, and the dates when the clock-stars pass the meridian towards midday or midnight are given.

These last are most useful additions.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 211. FEBRUARY. 1894.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, January 12, 1894.

Lieut.-Gen. **TENNANT**, R.E., F.R.S., *Vice-President*, in the Chair.

Secretaries: H. H. **TURNER**, M.A., B.Sc., and E. W. **MAUNDER**.

THE Minutes of the last Meeting were read and confirmed.

Mr. Maunder. 68 presents have been received since the date of the last Meeting. Those specially calling for remark are:—a work by Prof. Charles Dufour on the Scintillation of Stars; the first volume of a new edition, the fifth, of Webb's 'Celestial Objects for Common Telescopes'; the fifth volume of the German Transit of Venus Commission Report, which relates to the observations of the Transits of 1874 and 1882; and the third volume of Tisserand's 'Mécanique Céleste,' presented by the author. The other presents do not require special comment.

Mr. Turner, in referring to Mr. Marth's paper on a transit of Mercury across the Sun's disk, which would be seen from Venus on March 21, 1894, and on transits of Venus and Mercury which would be seen from Saturn on the same day, said that the work was one of those curiosities with which Mr. Marth sometimes favoured the Society. Mr. Marth was not content with calculating any and all phenomena which might occur to the inhabitants of our Earth, but did the same for those visible to the inhabitants of other planets; and it would perhaps be interesting to them in ages to come when they found that such events were enshrined in the historical calculations of our Society. The paper was a very short one, but no doubt its interest compensated for its brevity.

Mr. Turner next read a paper by *Prof. E. E. Barnard*, "On the Dark Poles and Bright Equatorial Belt of the First Satellite of Jupiter." The paper, Mr. Turner said, spoke for itself as regards its importance. It contained accounts of actual facts of observation, and those who had an opportunity of hearing Prof. Barnard a few months ago at the Society's meeting would be able to appreciate the weight of his words.

Dr. Spitta said that this paper was one of peculiar interest to him, inasmuch as it recalled a large number of experiments he had undertaken some time ago on the subject of contrast and with respect to the falling off in the amount of light reflected from different portions of a sphere. As he read the paper so many years ago, the exact figures escaped his memory, but it seemed to him the peculiarly shaded appearance of the satellite at the poles, and the brilliancy at the equator, as shown in the drawing handed round, was due to the falling off of the light in accordance with what he should expect from the experiments and figures obtained, rather than to a peculiar location of brilliancy in different portions of the satellite, which was a thing most difficult to understand.

Mr. Ranyard said it seemed a remarkable conclusion that Mr. Barnard had come to, if they were obliged to believe that this small body was in the same heated condition as Jupiter, and that the darkness of its poles was probably caused by gaseous absorption; for they had usually assumed that a small body radiated faster than a large one by reason of its larger surface compared with its mass, and that consequently a small body would become cold long before a larger neighbouring body. But there was a possible way of accounting for the bright equatorial belt upon the satellite without assuming that it was in a very heated condition. It was possible that the satellite might be surrounded by an atmosphere in which there was an equatorial belt of white clouds which reflected the Sun's light, while in the polar regions they were able to see the dark body of the satellite.

The Chairman. I should like to ask the Fellows whether they have ever tried a claret-coloured light in examining the planet. Many years ago I was induced to use a glass of that colour in the eyepiece by reason of a remark made by Sir John Herschel, and found, very much to my astonishment, that it brought out many more details in Saturn, Mars, and Jupiter than could be seen with a clear light. It seemed to cause a contrast which enabled me to see many details which could not be seen in any other experiment.

Dr. Spitta said the power of apparently producing details by the alteration both in the intensity as well as the colour of the light was a consideration of the greatest moment. No one present who was familiar with the use of the microscope could deny the truth of the statement. It was due to two things, partly to the peculiar property of the human eye, which demanded for perfect vision that the object should neither be too bright nor too faint, and secondly that the object should not be represented by too many coloured images at one and the same moment. It was here that the coloured glasses came in, for it is evident that the more monochromatic the light the more perfect the image. Imperfections, too, in the telescopic image would also have their bearing on this point.

The Chairman said there was a particular charm about that coloured light.

Mr. Maw. I have on several occasions examined Jupiter in the way General Tennant describes, and can quite confirm what he has said.

The Chairman asked if Mr. Maw had tried the red light.

Mr. Maw. Yes; I have tried the red, green, and blue lights. As regards the degradation of light towards the poles, I do not think that Dr. Spitta's explanation quite covers the ground.

Miss E. Clerke said the similarity of density of the satellites and Jupiter tended to show that they were in much the same physical condition.

The Chairman. With reference to what has been said about the monochromatic light, the claret-colour is by no means monochromatic. It has a great deal of blue as well as of red light in it. I have an idea that Sir John Herschel's remark was with regard to bluish stars, which would show out against the light. It certainly seemed to me that the planet and all its details were infinitely more clear when observed in a field of this claret-colour.

Mr. Turner thought the Society might congratulate Prof. Barnard on not only having discovered the new satellite of Jupiter, but on having discovered a circumstance of some importance in connection with the first satellite of Jupiter. As to the similarity of conditions on the satellite and on the parent body, and especially the presence of an atmosphere, the absence of the atmosphere on the Moon has been explained by the great difference of mass between the Moon and the Earth; and it was said that water and air were absorbed into the Moon much more rapidly than into the Earth; and if that hypothesis had any basis in fact, it would apply much more to Jupiter and his system. It would seem to throw considerable doubt upon the possibility of a clouded envelope around a satellite when they knew their own was so devoid of atmosphere.

Dr. Isaac Roberts then read a paper on, and showed photographs of, Nebula ♅ I. 200 Leonis Min. (the photos were taken on 19th March, 1893, with an exposure of 3 hours), and of the Nebulæ ♅ I. 56 and 57 Leonis.

Mr. Waters. With reference to these beautiful photos I would like to make a remark on one matter. I fancy that Dr. Roberts uses gelatine plates for the slides; but if he used collodion plates I think a far greater contrast between light and shade would be obtained.

Mr. Ranyard thought that the granulation was due to the enlargement of the photos and that it was not due to the plates.

Mr. Waters. I was not alluding to the granulation. The collodion plates are absolutely transparent in the white, whereas the others are rather whitish.

Dr. Roberts said it was true that he used gelatine plates, but there was no particular reason excepting convenience.

Mr. Turner then read a paper by the *Rev. S. J. Johnson*, on "The influence of the Full Moon on the Weather." The title, Mr. Turner said, was rather alarming, but Mr. Johnson was thoroughly sound on the matter. Mr. Johnson had kept a record for many years of the state of the sky on the night of full Moon, and in the present paper he compared the numbers of occasions when each of the following state of things prevailed:—(1) Cloudy at moon-rise and clear at transit; (2) clear at moonrise and cloudy at transit; (3) cloudy throughout the evening; (4) clear throughout the evening. The figures showed almost conclusively that the presence of the full Moon in the sky had no effect in dispersing the clouds.

Capt. Noble congratulated Mr. Johnson on having collected some valuable evidence on a subject which was probably a popular fallacy. [He also referred to the improved lighting of the blackboard used at the Society's meeting, which was this evening illuminated for the first time by an improved method suggested by Dr. Spitta.]

Mr. Maunder read a paper from the Royal Observatory, Greenwich, on the "Mean Areas and Heliographic Latitudes of Sunspots deduced from photos taken at Greenwich, at Dehra Dûn (India), and in Mauritius." The paper consisted of tabular matter and showed first the very rapid increase of the spotted area from 1889 to 1893, and second, the heliographic latitude occupied by the spots. Since the minimum the northern hemisphere had been the most prolific in spots.

In reply to Capt. Noble, *Mr. Maunder* said that the last maximum had generally been fixed in Dec. 1883.

Mr. Turner said that a paper had been received from *Mr. A. Stanley Williams* upon the rotation of Saturn. Mr. Williams had for many years observed Saturn carefully, and noted the times of transit of spots over the central meridian, and he had deduced a number of facts about the rotation of Saturn which would need some confirmation, as they were dependent upon the observation of, and consequently upon the proper identification of the spots which had come to the central meridian. The observations themselves were of very great value, as coming from an observer of Mr. Williams's care and knowledge.

Mr. Turner, in calling attention to a paper from the Royal Observatory, Greenwich, on "Observations of Occultations of Stars by the Moon, and of the Phenomena of Jupiter's Satellites, made in the year 1893," pointed out that it included several observations of occultations of stars of the 7th magnitude, the times of which were not predicted in the 'Nautical Almanac.' The observations therefore entailed a somewhat protracted watch at the telescope. The 'Nautical Almanac' system had been to include all stars down to the 6th mag. for occultation at Greenwich. He did not know whether Dr. Downing would consider the advisability of enlarging this limit according to the age of the Moon. It would seem one of the possibilities of the future to have some attention paid to the proper limiting of the magnitude of stars which were to be observed.

Dr. Downing. I have from time to time considered whether it would be practicable to include stars of a fainter magnitude, but to give stars of half a magnitude fainter would be to multiply the number by 3, and that would be quite impossible. Then there was the smaller task—that of altering the limit of magnitude which determines the stars to be included, according to the age of the Moon. That would be a very troublesome business and quite out of our routine; but the matter shall certainly be considered when more important matters have been disposed of. I doubt, however; whether the result would be worth the trouble expended. I would take this opportunity of mentioning another matter. Any one who observes the eclipses of the satellites of Jupiter knows that for a period of 3 years none of the phenomena of the IVth satellite can be observed. I would suggest that it would be of great help to persons who investigate the orbits of these small bodies if during that period observers would measure the position of this satellite with reference to the centre of Jupiter.

The following papers were announced and partly read:—

E. E. Barnard. "On the dark Poles and bright Equatorial Belt of the first Satellite of Jupiter."

Isaac Roberts. "Photograph of the Nebulæ ♅ I. 56 and 57 Leonis."

Isaac Roberts. "Photograph of the Nebula ♅ I. 200 Leonis Min."

Royal Observatory, Greenwich. "Observations of Occultations of Stars by the Moon, and of Phenomena of Jupiter's Satellites, made in the year 1893."

Royal Observatory, Greenwich. "Observations of Brooks' Comet (*c* 1893)."

Royal Observatory, Greenwich. "Mean Areas and Heliographic Latitudes of Sun-spots, deduced from Photographs taken at Greenwich, at Dehra Dûn (India), and in Mauritius."

Royal Observatory, Greenwich. "Notes on the Preparations for the Work for the Astrographic Chart."

Rev. T. E. Espin. "On the Spectra of certain Stars (II.)."

Rev. T. E. Espin. "Some Nebulous Objects not in the New General Catalogue of Nebulæ."

Rev. S. J. Johnson. "Influence of the full Moon on the Weather."

A. Marth. "Ephemerides of the five Inner Satellites of Saturn, 1894."

A. Marth. "Ephemeris of the Satellites of Uranus, 1894."

A. Marth. "Note on the Transit of Mercury over the Sun's Disc, which takes place for Venus on 1894, March 21; and on the Transits of Venus and Mercury which occur for Saturn's system on the same day."

The following gentlemen were elected Fellows of the Society:—

Wm. Briggs, B.A., LL.B., F.C.S., Burlington House, Cambridge; *John H. Buckley*, 70 Tower Street, Leicester; *J. Evershed*, Jun., Kenley, Surrey; *Joshua Jukes*, 43 High Street, Smethwick, Birmingham; *H. A. Lenehan*, Sydney Observatory; *Prof. A. O. Leuschner*, University of California, San Francisco; *Henry MacEwen*, 5 Cathkin Terrace, Mount Florida, Glasgow; *Rev. D. P. Richards*, B.A., H.M.S. 'Canada,' Bermuda; *R. P. Sellors*, B.A., Sydney Observatory; *Dr. Max Wolf*, University, Heidelberg, Germany.

The following Candidates were proposed for election as Fellows of the Society:—

A. S. Ghosh, 28 Convent Road, Calcutta (proposed by A. C. D. Crommelin); *Lieut. Wm. H. F. Montanaro*, R.N., H.M.S. 'Canada,' Bermuda (proposed by Sir Josiah Rees); *Walter A. Post*, Civil Engineer, Newport News, Virginia, U.S.A. (proposed by S. W. Burnham); *Alexander Wm. Roberts*, Mathematical Master, Alice, Lovedale, Cape Colony (proposed by David Gill).

The Meeting closed at a quarter past nine.

ROYAL METEOROLOGICAL SOCIETY.

THE Annual Meeting of this Society was held on Wednesday evening, January 17th, at the Institution of Civil Engineers, 25 Great George Street, Westminster; Dr. C. Theodore Williams, President, in the Chair.

The Council, in their Report, stated that the Society had made steady and uninterrupted progress during the year, there being an increase in the number of Fellows, and the balance of income over expenditure being greater than in 1892. They also reported that Dr. C. Theodore Williams, previous to vacating the office of President, had expressed a desire for the formation of a fund for carrying out experiments and observations in Meteorology, and that he had generously presented to the Society the sum of £100 to form the nucleus of a Research Fund.

The President, in his valedictory address, gave an account of the climate of Southern California, which he made most interesting by exhibiting a number of lantern slides. In the autumn of 1892 Dr. Williams visited this favoured region, chiefly with a view of investigating its present and future resources and its suitability for invalids. After describing the entrance into California from Utah and Nevada, the general geography, and the mountain ranges, he pointed out that the mountain shelter is tolerably complete and that the protected area consists of (1) valleys, chiefly running into the coast range from the sea and rising to various elevations, such as the fertile San Fernando and San

Gabriel valleys, or else (2) more or less extensive plains, as those of Santa Aña and San Jacinto. Southern California is subdivided into two portions, eastern and western, by the Sierra Nevada and its spurs, the San Gabriel and San Bernadino mountains. The climate of the eastern portion, which is an arid region, is very dry, very hot in summer and moderate in winter. The climate of the western portion has three important factors, viz. (1) its southern latitude; (2) the influence of the Pacific Ocean, and especially of the Kuro Siwo current, which exercises a similar warming and equalizing influence on the Pacific coast of North America as the Gulf-stream does on the western coasts of the British Isles and Norway; and (3) the influence of mountain ranges—these affording protection from northerly and easterly blasts, and also condensing the moisture from the vapour-laden winds blowing from the Pacific. Dr. Williams then gave particulars as to the temperature and rainfall at Los Angeles, San Diego, Santa Barbara, and Riverside. From these it appears that the climate of Southern California is warm and temperate, and, on the whole, equable, with more moisture than that of Colorado; and that it is a climate which would allow of much outdoor life all the year round.

Mr. R. Inwards, F.R.A.S., was elected President for the ensuing year.

Telescope Mountings and Domes.

During last summer Prof. W. H. Pickering, of Harvard, spent some time on this side of the Atlantic and visited several observatories in England and on the Continent. He gives some impressions derived from his experiences in an article under the above title in *Astronomy and Astro-Physics* for January, from which the following extracts are taken.

Writing of the methods of controlling the driving-clock of an equatorial telescope, he says :—" There is a very convenient device of general application which is employed at Greenwich, but whose bearing in the present instance does not at first sight appear. When it is wished to correct the error of the standard meantime clock, it is not done by adding or removing small weights from a scale pan, as is customary at many observatories. Instead of this there is attached to the front of the pendulum of the clock a vertical permanent bar magnet, measuring $5 \times \frac{3}{8} \times \frac{1}{8}$ inches. Just below the magnet is placed a helix attached to the clock case. It is connected with a battery of eight Leclanché cells, and has no iron core. By passing a current through this helix in one direction or the other the error of the clock can be changed by six seconds, inside of one hour. In talking this matter over with Mr. Douglass afterwards it appeared that this arrangement might be adapted to the control clock of an equatorial. It would probably be best in order to change the rate more rapidly to employ two helices, one above and one below the magnet, and to furnish them with iron cores. By this arrangement no slow motion screw and no 'mouse control' would be necessary. An electric current would merely be passed through the helices the intensity and direction of which could be varied by turning a switch held in the hand. Like the 'mouse control' this adjustment would never come to an end, and it would have an advantage even over it in one respect. If in following a star we found that it was gradually leaving the crosswires, we should not be obliged to continually bring it back again every few minutes, as soon as we were able to detect an appreciable error in its position. We should do better than that. We could pass a slight current through the coils and change the rate of the clock, so that no error of position should occur,—and this without disturbing the driving mechanism in the slightest degree. It seems to me that we have here a new principle of following,—instead of constantly correcting the error of the clock, as the star varies its position, we merely correct the clock rate." This seems a useful suggestion: as a mere detail, a rheostat or other apparatus should be added for varying the current sent through the coil.

Prof. Pickering also makes some suggestions for the construction of a telescope building and dome as follows:—"They are particularly adapted to the mounting of a large telescope, but some of them may perhaps be of use in the case of a smaller instrument. It seems to me that the cheapest and lightest form of building that could be erected to cover a large telescope would be built upon the plan of a large railway depot. In figure 7, which is a plan of the dome, a steel ring is first laid to form its base. On this a series of parallel steel arches are erected of suitable sizes. These are united and braced by a series of cross ties giving the structure its final form. For small domes wood could be used as a substitute for steel. The whole is then either covered with sheet metal, or perhaps better still with galvanized iron netting. Finally the netting is covered with water-proofed canvas. It has been found at Greenwich that netting covered with papiermaché stands the climate very well, and we have found in Cambridge that the same is true of canvas stretched upon wood. It therefore seems that a covering such as is here suggested might withstand very well even the rigors of a northern climate. The shutters of the dome should slide horizontally according to the Hough or Warner, Swasey plans. The dome should be mounted upon a cylindrical iron framework, covered with one thickness of sheet iron. It is almost universal in Europe to mount the domes upon a heavy base of masonry, which collects and retains the heat well into the night. This principle seems to me to be radically wrong. We have gone to the opposite extreme at Harvard, the buildings supporting the later domes consisting of a light wooden framework covered with a single layer of thin sheathing. Our experience there and particularly at Arequipa, I think fully justifies our method of reasoning.

"Permanently attached to the side of the dome, opposite the shutter, should be placed the curved rails on which the chair is to be raised and lowered. The chair, so-called, is a large structure, more nearly comparable to a small room, or perhaps better still to a theatre box. It is furnished with an invalid's reclining rolling chair with book rack attached, for making observations near the zenith, with several ordinary chairs, a case of drawers for eyepieces, etc., a table and book-shelves for a recorder, mean and sidereal clock dials controlled electrically, and with suitable sounders which can be thrown into the circuit when desired. The motions of the dome, shutter, and chair, which latter is partly counterbalanced by weights moving upon the opposite portion of the dome, are all necessarily moved by an electric-motor, which may be controlled from the chair. The telescope would be clamped in right ascension by the pressure between an electro-magnet and its armature. The clamp could thus be instantaneously applied."

This observing box is ideal, but at first sight it looks as though there would be mechanical difficulties in the way of attaching such a massive construction to the light dome on the light foundation that Prof. Pickering suggests above. Anything attached to the dome is of course almost impossible with an English mounting, for it would be liable to foul the piers; and even with a German mounting it would be necessary to move telescope and dome together to avoid fouling. As regards the iron framework, is it not likely that this would get so hot during the day as never to cool down at all? The interior of a dome built on masonry is usually quite cool even in the daytime.

The suggestions of Prof. Pickering and those of Prof. Harkness on designing instruments by differential equations, which we print on p. 88, are, however, well worthy of the fullest consideration, and we shall hope to elicit something in the way of comment from Mr. Maw and our other readers skilled in such matters.

Selenographical Notes.

TRIESNECKER AND THE RILLS.—Notwithstanding its favourable position in a region abounding in interesting detail, this prominent little ring-plain, with its complicated rill-system, receives far less attention from lunar observers than it deserves. It is true that Mädler made it the subject of a separate chart, and that Schmidt mapped its surroundings with special care, yet no one can devote a few favourable nights to the observation of the neighbourhood without discovering that very much remains to be done before it can be said that we possess even a tolerably correct representation of this particularly noteworthy part of the Moon's surface.

Triesnecker occupies the highest part of the Sinus Medii, standing in the midst of a district which, irrespective of the evidence afforded by the clefts, bears unmistakable signs of disturbance in the form of corrugations and inequalities in the surrounding surface. If observed under a morning Sun when the long. of the terminator is about 1° west of the central meridian, the ruggedness of the ground on the north and east is prominently displayed. At this phase, also, the ring presents a very striking aspect, resembling a breached cone with a wide opening towards the north. This apparent gap in the border has, however, no real existence, and is merely due, as is so often the case with other formations, to the shadow of a loftier portion of the wall obscuring a section having less altitude. The rim of Triesnecker, in fact, appears to be perfectly continuous, and exhibits no visible breaks or passes, and only a longitudinal valley on the east (not shown in the maps) which does not interfere with its continuity. An inner ring or terrace, conspicuous under a higher Sun, is, however, even more broken up into sections than is indicated by Schmidt. Under the conditions just specified, the shadows thrown by the border, those of the spurs and buttresses associated with it, and of the neighbouring ridges are very remarkable and suggestive. One of the most prominent of the latter, sweeping northwards in a bold curve from the west side of the apparent gap and forming a distinct line of demarcation between a low-lying and loftier region, seems to point to the existence "of a fault" in connection with the ring-plain. The peculiar form of a shadow of a spur from the south-east wall in a line with this feature tends to support this supposition.

The rill-system of Triesnecker is certainly the most interesting on the Moon's visible surface. The only other system which at all resembles it is that associated with the little ring-plain Ramsden. In both we have the peculiarity of clefts radiating from common centres, but the Ramsden group cannot be compared as regards number and intricacy with those under consideration. In one of his articles on Lunar Formations in the 'English Mechanic,' Birt likens the Triesnecker rills to an "inverted river-system," a simile which will commend itself to all who have seen them under favourable conditions; for in many instances they appear to become wider and generally coarser in approaching higher ground. The discrepancies in the published representations of them are more pronounced with respect to that part of the system which lies north-west of the ring-plain (*i. e.* between it and Hyginus) than elsewhere. Both in Mädler's special chart and in Schmidt's and Neison's maps the two principal southern clefts (β and ζ in Neison's Map II.) running from Rhæticus A and from the mountains north of Rhæticus respectively to a point near the foot of the west wall of Triesnecker, together with a connecting cleft about midway, are shown without any notable difference. β and ζ are not difficult. I have seen them easily in a $3\frac{1}{4}$-in. achromatic, and it seems very strange that Schröter should have overlooked the coarser portions of them. The connecting rill is much more delicate. In the maps just referred to it is drawn as making a junction with ζ and not extending further towards the east. On April 14, 1883, 8h, however, I traced it for a considerable distance in this direction, and in an excellent sketch of the rills by M. Gaudibert ('Journal of the Liverpool Ast. Soc.' vol. iii. pt. 1, p. 20) it is also drawn thus. A plate in Klein's 'Durchmusterung des Himmels,' p. 200, shows it as originating a long way west of β and, after crossing this cleft and ζ, extending eastwards and ending in a fork. I have tried in vain to see this western branch, but Gaudibert draws one a little north of the point of crossing which possibly represents it. All the drawings I have made of the Triesnecker clefts agree in showing the more westerly of these features, north of the ring-plain, as really consisting for a great part of its length of two distinct slightly curved furrows, closely parallel, the more easterly of these objects running a little to the east of the large crater *a* south of Hyginus, thus according with Schmidt's representation of them, but being utterly at variance with Mädler's and Neison's. The other clefts north of Triesnecker, as shown by Schmidt, lie mostly in narrow valleys trending in a northerly direction from this formation. They are nearly all of a very delicate type, a circumstance which accounts for the striking want of agreement, as regards their location, in the maps. There is a row of four hillocks on the north of Triesnecker, forming, roughly, a tangent to the border, which is always more or less prominent under a low angle of illumination. The most easterly of these features was seen by me as a distinct craterlet at 6h on November 28, 1881, and on two subsequent occasions. I suspect they are all of the same character, though Schmidt shows them as circular mounds. On April 11, 1886, 8h to 9h 10m, I traced the cleft ζ round the eastern slope of Rhæticus. It follows the curve of the ring and ultimately runs along a spur projecting from the south wall of the formation.

Beaumont House, Shakespeare Road,
Bedford, 1894, Jan. 20.

THOS. GWYN ELGER.

Large Detonating Fireball.

ON Jan. 25, at 10h 1m, a slow-moving fireball of the most brilliant kind was observed by Mr. Denning at Bristol, by Mr. Wood at Birmingham, and by many other observers in various parts of the country. The fireball illuminated the cloudy sky with a series of vivid flashes, and divided into fragments before its extinction. At Worcester, Droitwich, and other places in that locality, the detonation shook the houses and rattled the windows so violently that people rushed out of doors in an alarmed state. At Ashchurch, near Tewkesbury, Glos., there was a report like a clap of thunder, and people thought there was an earthquake, as there was a perceptible oscillation for a few seconds. At Birmingham the report followed the meteor's disruption by 3 minutes, according to two independent observers. Mr. Denning finds that at its explosion the fireball was only 16 miles above a point 4 miles N. of Ashchurch, and that the earth-point was 35 miles further on, in the path terminating at Swindon. The fireball was probably seen when crossing above Chester at a height of 58 miles, and it passed almost vertically over Droitwich and Worcester at a height of about 23 miles, finally collapsing, as already stated, when N. of Ashchurch. The radiant-point appears to have been near α Cephei; but the observations are not quite accordant in their indications.

W. F. Denning.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Present Value of Lunar Photography.

Gentlemen,—

It is of course largely a matter of opinion as to what may be considered to be an under-estimate of the value of such a thing as photography when applied to selenography. I should like, however, to mention that the opinion on this point, to which Mr. Elger takes exception ('Observatory,' No. 210, p. 49), was not formed hastily or without due consideration for the latter's various contributions on the subject. But these, important and interesting as they always are, have usually given me the impression, whether rightly or wrongly, that in the opinion of their author, the results of lunar photography are distinctly inferior to visual observations as regards the detection of minute or delicate objects *of every kind*—so much so, indeed, as to make a telescope of say 4 or 5 inches aperture capable of showing visually practically everything indicated by the best photographs. It may be well to state that I am quite in agreement with Mr. Elger as to the "desirability of exercising a little philosophical caution before accepting as actual lunar structure *everything* displayed in these very beautiful pictures." Photographic defects are in fact at the present time far too common. But it it possible to carry this principle too far, so as practically to accept *nothing* unless it has been actually confirmed by visual observations. Whereas the only crucial test of the existence of a photographic detail must be found in photography itself.

Whilst on this subject I would draw attention to an important division of selenography, in which photography can be of immense assistance at the present time: that is, the division concerned with the determination of the positions of lunar objects. This branch of selenography, it must be confessed, is at present in a very imperfect state. The points of the first order of Mädler are far too few in number, and most of them lack the degree of accuracy which modern requirements demand. The majority of the existing positions were determined many years ago by means of small telescopes, sometimes even unprovided with clockwork. In work of this kind photography has peculiar advantages. Not only can the measures be made with the accuracy of the best modern micrometric work, but the labour of calculation would be considerably reduced. For many of the necessary reductions, when once made for any particular plate, would serve for the determination of any number of positions. It would probably be advisable in work of this kind to measure from the two standard objects Manilius and Mösting A, as suggested by Mr. Neville on p. 543 of his work on the Moon, instead of from the Moon's limb; as thereby any uncertainty as to the amount of photographic irradiation would be avoided. It would probably also be advisable to impress the plates intended for this purpose with some form of réseau, to guard against any distortion of the film.

Yours faithfully,

West Brighton, 1894, Jan. 17. A. STANLEY WILLIAMS.

Nomenclature of Jupiter's Satellites.

GENTLEMEN,—

With reference to Mr. Lynn's remarks on this subject there is evidently a difference of opinion as to the utility of retaining and employing the names given by Simon Marius to the satellites of Jupiter. Prof. Young takes an affirmative view of the case, or he would not have used the names; and I presume that Dr. Downing entertains a similar opinion, for he pointedly refers to Jupiter's satellite Callisto without giving the Roman numeral (see 'Monthly Notices,' Nov. 1893, p. 25). For my own part I must confess to a preference for specific titles rather than numbers, as their general adoption would be consistent with the plan followed in regard to the satellite systems of Mars, Saturn, and Uranus. Galileo's claim as the first discoverer of the satellites is incontestable, and cannot be affected by the acceptance of the names suggested by Marius. That three of these names have been applied to planetoids shows bad judgment on the part of those who selected them for that purpose, and the same may be said with reference to the naming of No. 106, for it was scarcely advisable to call it Dione, thus initiating a source of confusion with Saturn's fourth satellite. Nor was it desirable that the names of several of the Pleiades should be given to planetoids, as, for example, Maia (66), Electra (130), and Asterope (233). This repetition ought to have been specially avoided as likely to introduce complications.

I believe the opinion is gaining ground that the Jovian satellites should be called by distinguishing names, and it would be satisfactory, in view of this eventuality, if the discoverer of the fifth satellite selected a suitable title for it.

Yours faithfully,
Bristol, 1894, Jan. 8. W. F. DENNING.

GENTLEMEN,—

I most heartily concur with Messrs. Freeman and Lynn in their deprecation of any change in the designation of the four familiar satellites of Jupiter. These bodies have been, practically, universally known as Satellites I., II., III., and IV. from time immemorial, and to change this most simple description (at once the easiest to remember and the expression of a physical fact) for mythological nuncupation seems to me to be the merest pedantry.

There appears to be a recent tendency to alter celestial nomenclature simply for the sake of alteration. Take, as an illustration, the planet Mars, certain regions of and markings on which were widely and familiarly known to all areographers by the names given to them in the maps of Proctor, Green, and other recognized authorities. All this has been upset by Signor Schiaparelli, with his most cacophonous re-naming of the principal features of the planet, which it takes a very long time to learn, is so easy to forget, and which, but for the invaluable globe constructed by M. Niesten, of the Belgian Royal Observatory, would render some of the more recent descriptions of the surface of Mars unintelligible to a large proportion of observers.

It is very easy for any possessor of Lemprière's Dictionary to earn a cheap reputation as a classical scholar by affixing the names of those "Heathen Gods and Goddesses," who (as Byron hath it) "went without their pantaloons and bodices," to planetary detail. But let us, whose sole end is the service of astronomical science, take heed to the good old motto "Stare super vias antiquas," and set our faces against change merely for change's sake.

Faithfully yours,
Forest Lodge, Maresfield, Uckfield, WILLIAM NOBLE.
Sussex, 1894, Jan. 8.

GENTLEMEN,—

As my friend Mr. Freeman remarks, I had overlooked that not only Io and Europa, but Callisto also, have been appropriated as names of small planets, showing the general feeling of astronomers that Mayr's suggestion of them as names for Jovian satellites should not be recognized; for names which do not distinguish without the addition of other designations are of little value.

Galileo's own suggestion of individual names for the satellites from members of the Medicean family has also been generally rejected; and it seems to be an established principle in modern times that earthly patrons are not to be exalted to the skies by astronomical discoverers. One does not see why it should not be sufficient to call the old four the Galilean satellites, with the original numbers (which have almost become equivalent to names) I., II., III., IV.

With regard to the new satellite, we are on different ground. One lives (and we all hope he may long live to enrich astronomy still further) who has an undoubted right to name it. Mr. Freeman suggests to call it provisionally the B satellite of Jupiter, partly apparently because B is the initial of Prof. Barnard's name, and partly because it would be appropriate if it turns out that there is another satellite (in that case to be called A) still nearer to Jupiter. But supposing there be another farther from Jupiter and yet within the orbits of the Galilean satellites?

The curious empirical progressions developed by M. Gaussin in 1880 (see 'Comptes Rendus,' tome xc. p. 518) do not seem to have attracted much attention in this country. He expresses the successive distances of the planets from the Sun and of the satellites from their primaries by the formula $a = \alpha k^n$, where k is the mean geometrical proportion for the secondaries, n has its successive values as an exponent, and α is taken so as to be not far from unity (in the case of the planets he finds it almost exactly unity). Where n is unity he takes the corresponding distance to be that of the satellite (or planet) nearest to the centre of the system. If a gap occurs, it indicates the place of a body not yet discovered. In this way he finds that the first Galilean satellite of Jupiter is really the third in the progression, but that the three others are afterwards continuous. It must be remembered that this was written before the discovery of Prof. Barnard's satellite, and that it points to two interior to the Galilean, one of which wonld nearly correspond in distance to the new fifth and the other would be exterior to it, the distances of these two from Jupiter being approximately 2·19 and 3·60 in terms of the semidiameter of the planet. The former is remarkably near the distance of the satellite discovered in 1892, and gives some probability to the existence of another exterior to it, which we must suppose to be still smaller or, at any rate, fainter, as it has not yet been seen. Should Prof. Barnard discover such a one, we might provisionally designate the two interior satellites Barnard I. and II., and it would be a considerable confirmation of M. Gaussin's theory, which, I may add, makes Ariel the fifth satellite of Uranus and Mercury the eighth planet in order of distance from the Sun.

Yours faithfully,

Blackheath, 1894, Jan. 12. W. T. Lynn.

Mr. Tebbutt and the Transit of Venus, 1874.

Gentlemen,—

In the 'Observatory' for October 1893, p. 361, under the heading "Observatories," you refer to Mr. Tebbutt's complaint that his work was not referred to in what he incorrectly calls Mr. Russell's Government Report of the Transit of Venus, 1874.

I was not surprised that Mr. Tebbutt should make this complaint after my experience of others which have gone before it, but I was surprised that you, with the book in question before you, should ask for an explanation.

The work is not a Government Report of the Transit of Venus in 1874, in which Mr. Tebbutt is "denied the right to be styled a New South Wales observer," but it is a Report of the "Observations of the Transit of Venus made at stations in New South Wales *under* the direction of H. C. Russell, Govt. Astronomer," in which it would obviously have been impossible to include Mr. Tebbutt's work, for he acted quite independently of me both in observing and publication. Others besides Mr. Tebbutt, who observed in this colony, were necessarily passed over for the same reason; I had no right to include their work in a report which was never meant to include all that was done in New South Wales; and in order that there should be no misapprehension, I stated in the most conspicuous place in the book that it referred *to those under my direction.*

Yours faithfully,
H. C. Russell.

Observatory, Sydney, 1893, Nov. 23.

[We think that if Mr. Russell will refer again to the 'Observatory' for October 1893, he will find that we scarcely ventured to "ask for an explanation." Since, however, he has offered one, we feel bound to say that after reading his letter, and looking again carefully at the volume in question, we sympathize with Mr. Tebbutt. —Eds.]

The Royal Astronomical Society Club.

Gentlemen,—

Could you kindly find space in your magazine for the following announcement, which I wish to bring to the notice of Fellows of the Society?—

"The Members of the Royal Astronomical Society Club intend dining together at the 'Criterion,' Piccadilly Circus, after the Annual Meeting of the Royal Astronomical Society on Feb. 9, and will be glad to have the company of any Fellows of the Society who may wish to join them. An intimation of such intention to Dr. Common would be welcome. The dinner will be on the table at 6 o'clock, and the cost, including wine, will be twenty shillings."

I am, Gentlemen,
Yours truly,
A. A. Common.

OBSERVATORIES.

[Continued from p. 54.]

Prag (University). *L. Weinek.*—The exquisite photographs of the Moon taken at Lick impelled Prof. Weinek to give increased attention to his drawings, the result being that he devoted 332·5 hours in 1892 as against 296·25 in 1891. The greater part of this time was given to the walled plains of Vendelinus and Langrenus. The latitude observations according to the Talcott-Horrebow method began in 1891 were continued in 1892 to May, when the corresponding observations in Honolulu were ended. In all 506 pairs were observed. The great sun-spot of Feb. 1892 received great attention. For the lunar eclipse of May 11 the 6-inch was utilized in observations of the passage of the Earth's shadow over a large number of lunar formations, and for the occultations of stars 4091, 4093, 4095, and 4099. Similar work was done during the lunar eclipse of Nov. 4. The occultation of Uranus by the Moon was observed on 1892 March 16. A number of other occultations were observed throughout the year, as well as the phenomena of Jupiter's satellites. Positions of Comet Holmes were secured. Time-service. Meteorology. The publications of the observatory in 1892 were

1. Magnetische und meteorologische Beobachtungen, 1891;
2. Astronomische Beobachtungen in dem Jahren 1888–91.

The latter contains a number of plates exhibiting some of Dr. Weinek's lunar drawings.

STRASSBURG. *E. Becker.*—Work with the 18-in. refractor was hindered for two months during the repairing of the dome. Observations of Comets 1891 II. (Wolf), 1892 I. (Swift), 1892 II. (Denning), 1892 III. (Holmes), 1892 IV. (Winnecke), Brooks (Aug. 27), Barnard, Brooks (Nov. 19), besides

115	determinations	of positions	of nebulæ.
47	”	”	comparison stars.
3	”	”	planet Thule.

The Repsold meridian-circle was used for stars in zone −2° to −6°, for fundamental stars, and for the Moon and planets (a fairly good series). Equatorial and polar diameters of the Sun were obtained with the heliometer. A series of observations for variation of latitude in connection with those at Prague, Honolulu, &c. were made. Drawings of Mars during opposition.

TURIN. *T. Porro.*—This observatory possesses an 11-in. refractor by Merz, which is optically of fine quality, but is badly mounted. There is also a 3½-inch Fraunhofer, used for observations of variable stars. Apparently little, if anything, is done with the larger instrument. Time determinations. Meteorology.

UPSALA. *N. C. Dunér.*—A new refractor has been installed. It has two objectives—one for ordinary work of 36 cm. and 5·3 metres focal length, the other 33 cm. aperture and 4·7 metres focal length for photographic work. The illumination is by electric light. No observations have yet been made. With the 162 mm. refractor numerous observations of variable stars have been made. The ordinary transit- and vertical-circle observations have been continued.

WIEN. *L. de Ball.*—This is a private observatory founded by M. Edler von Küffner. It possesses a 10-inch refractor, properly equipped with position- and ring-micrometers, helioscope, Airy's double-image micrometer, and a small spectroscope; a 6-inch photographic refractor, with apparatus for measuring the plates; a 4½-inch meridian-circle; a transit in the prime vertical; and two clocks and two chronographs. In 1894 a 4-inch heliometer is to be added. The electric light is being installed. Zone observations −6° to −10°. With the 6-inch photographs of the following were secured:—G.C. 584, 1166, 1295, 1360, 4346, 4361, 4367, and 4437. The reduction of the measures is not yet complete. The observatory and staff have been extended greatly during the past year.

ZURICH. *Rudolf Wolf.*—Observations of sun-spots and collections of sun-spot statistics. Dr. Wolf has now been 45 years engaged on this subject. His results for the last two years are:—

	Number of observing days.	Sun free from spots on	Relative numbers.
1891	320	18	35·6
1892	291	0	73·8

This is Dr. Wolf's last report. With regret we recorded his death in our last issue.

HARVARD COLLEGE. Extracts from Prof. PICKERING'S Report for the year ending October 31, 1893.—The most important event to be mentioned in the present report is the completion of the new fire-proof brick building, and the transfer to it of about 30,000 stellar photographs. The second expedition to our Peruvian observing-station has returned, and the third expedition has begun work successfully. The entire income of the Paine Fund, one of the largest gifts ever made to astronomy, is this year for the first time available for the use of the observatory. The expense of the second Peruvian expedition proved much greater than was anticipated, and has caused a considerable deficit in the Boyden Fund. The expenses for publication which are to be paid from the unrestricted portions of the income of the observatory are likely to be large in coming years, and if possible a portion of the income should be reserved for a building fund, which will soon be required if the observatory maintains its present rate of growth. The observatory was represented at the Chicago Exhibition by a collection of about 250 photographs, and portraits of Bond, Paine, Boyden, and Draper.

Variable stars, Jupiter's satellites, comets, and meteors were observed with the equatorials, and the reduction of the meridian work is progressing favourably.

Meridian Photometer.—Good progress has been made in the reduction of the photometric observations of the southern stars made in Peru by Professor S. I. Bailey. A portion of the catalogue is in type and the remainder is ready for the printer. Observations have been made by the Director with the meridian photometer on nearly every clear evening during the past year. The number of series is 107, and of separate photometric comparisons 46,272. The observations ordinarily last from seven to eleven in the evening; but last summer they were extended to one or two o'clock in the morning, in order to complete the observation of the large number of stars in the Milky Way which can only be observed at that season. The observing list contains about 6000 stars, including the 4000 contained in the Harvard Photometry, which are thus reobserved. About three quarters of the observations required to complete this list, each star being observed on at least three nights, have now been made.

Henry Draper Memorial.—The number of objects having peculiar spectra, which are annually discovered by Mrs. Fleming in her examination of the Draper photographs, has not diminished. The most important of these objects is a new star in the constellation Norma, whose spectrum was photographed at the Arequipa station on July 10, 1893, and of which no trace was visible on 13 plates taken from June 6, 1889, to June 21, 1893. Its spectrum appears to be identical with that of the new star which appeared in Auriga in December 1891. Seven variable stars—T Cassiopeiæ, S Geminorum, T Geminorum, S Virginis, V Boötis, R Piscis Australis, and S Aquarii—in addition to the 47 previously announced, have the hydrogen lines bright in their photographic spectra. Three new variables have been discovered this year by means of this property. The number of stars of the fifth type has been increased by 10, making the total number now known of these objects 55. The hydrogen line F has been discovered to be bright in the spectra of BD. $-13^\circ{\cdot}893$, mag. 5·8, and $-19^\circ{\cdot}1786$, mag. 7·3. Ten stars have been shown to have spectra of the fourth type.

Boyden Department.—The second Peruvian expedition, under the direction of Professor W. H. Pickering, returned to Cambridge last spring after successfully observing the Total Eclipse of the Sun on April 16, 1893. Surveys were made which determined the positions and altitudes of various points in the Sorata range in Bolivia and of Mt. Aconcagua in Chile. The most important astronomical work undertaken was the study of the members of the solar system by means of the 13-inch Boyden telescope. This included a study of the lunar rills and of variable spots upon the Moon and catalogues of them; of the diameters of the satellites of Jupiter, of their elongated shapes, the inclination of their axes of form, their axes of rotation, their markings, and the determination of the retrograde rotation of the first satellite; also a study of the markings of the planet Neptune. A series of measurements was also made of the double star α Centauri. These observations confirm the conclusion that the atmospheric conditions at Arequipa are particularly favourable for astronomical observations. It is extremely important that we should avail ourselves of the opportunities thus afforded by erecting at this station a telescope of the largest size. If this cannot be done, a telescope of 20 or 25 inches aperture would add greatly to our present knowledge of the surfaces of the planets and of other objects for which great magnifying powers are required. It is hoped that this matter will be borne in mind by those who wish by their gifts to advance astronomical science. The number of photographs taken with the 8-inch telescope was 250, with the 13-inch, 112. These numbers would be greater but that the cloudy season is included in the portion of the year here under consideration.

The third expedition, under the direction of Professor Solon I. Bailey, began work on April 4, 1893. Since then 1516 photographs have been taken with the 8-inch telescope and 852 with the 13-inch telescope. An eyepiece has been attached to the latter instrument so that the motion of the telescope may be controlled by an image formed by its own objective, thus dispensing with a finder. Very remarkable photographs have thus been obtained of the principal southern clusters. On a photograph of ω Centauri over 7000 stars were counted by Professor Bailey in a region 30′ square. Two of these stars have been found to be variable, one being discovered by Mrs. Fleming, the other by the Director. Professor Bailey has shown that three stars are variable in the cluster 47 Tucanæ. The images of the stars in these clusters are almost perfectly circular, although the exposure in some cases exceeded three hours. 104 photographs have heen obtained with the 2½-inch Voigtländer doublet. The brightness of about one half of the stars south of declination —30°, and brighter than the magnitude 6·3, has been determined visually.

Until recently the highest meteorological station in the world has been that established by this observatory on Mt. Chachani at an elevation of 16,650 feet. After making a careful examination of the volcano El Misti, Professor Bailey has succeeded in establishing a station upon its top at an elevation of 19,200 feet. A path has been constructed by which mules have been led to the summit, and beside the meteorological shelter a wooden hut has been built upon the summit. A survey of the craters has been made, and a stone hut has been erected on the side of the mountain at a height of 15,600 feet. The temperature, pressure, moisture, and the velocity and direction of the wind are now being recorded at the summit station by self-registering instruments. The sheets are changed at intervals, thus giving a record of atmospheric conditions at a height hitherto unattempted. The use of beasts of burden at these heights offers an opportunity in the future of carrying instruments and conducting experiments at altitudes heretofore regarded as inaccessible for these purposes. The mountain as seen from every direction is an isolated sharp peak. It is therefore especially suited for the study of the upper atmosphere.

The Bruce Photographic Telescope is now nearly completed, and photographs will be taken with it in a few days. So far as can be judged at present it seems likely to accomplish all that has been expected of it. The brick building with sliding roof to contain this instrument is finished, and a large part of the mounting is in place.

U.S. NAVAL OBSERVATORY, WASHINGTON. Extracts from the Report of the Superintendent.—"On May 15, 1893, the old Naval Observatory, Twenty-third and E Streets, Washington, D.C., was formally abandoned as an observatory and the new site on Georgetown Heights, Washington, D.C., officially occupied.

"On October 2, 1888, a contract was awarded by the Navy Department for the erection of the buildings for a new Naval Observatory, with necessary offices for observers, stipulating that the work should be performed by April 2, 1890. This contract was extended from time to time until forfeited on September 8, 1891. After the preliminaries of inventory, valuation, and advertisement, a new contract for the completion of this work was entered into on February 16, 1892, which provided that the buildings should be finished by June 1, 1892. This time was, however, extended until February 11, 1893, when the buildings were accepted by the Government.

"During the progress of the construction of these buildings amongst other contracts were: for repairing and remounting the great equatorial (26-inch) and its accessories, including observers' elevating platform; for repairing and remounting the meridian circle and its accessories; for repairing and remounting the transit instrument and its accessories; for repairing and remounting the prime vertical transit instrument; for furniture and gas or electric fixtures for main building, great equatorial building, clock buildings, transit houses, boiler house, and magnetic buildings; for a new meridian circle (6-inch objective).

"Few observations of the heavenly bodies have been made since my last annual report, as all the principal instruments were undergoing repairs. The naval officers, assistant astronomers, and computers have been engaged in supervising and inspecting instruments and their accessories while being dismounted, repaired, transferred, remounted, and adjusted; in establishing the position of the new Naval Observatory (latitude $38^\circ\ 55'\ 14''\cdot68$ north, longitude $5^h\ 08^m\ 15^s\cdot71$ west of Greenwich), and in the reduction and preparation of the observations on hand."

The above notes are from the report of F. V. McNair, Captain U.S. Navy, Superintendent of the Naval Observatory. The remaining notes are from Appendix B of the Report, by Prof. Harkness:—

"The building of the new mountings for the 12-inch and 26-inch telescopes, and the reconstruction of the prime vertical transit instrument, were effected under my supervision as inspector, and I have prepared the detailed specifications for the new 6-inch transit circle.

"Starting from very small dimensions, astronomical telescopes have grown until the weight of the machinery which carries them is now reckoned in tons. So long as the parts were small it sufficed to proportion them by the eye, but when the polar axis attains the size of the screw shaft of an ordinary steamer it becomes necessary to have exact formulæ similar to those used in the designing of steam engines. No such formulæ were available, but the Observatory library contains drawings and descriptions of nearly all the great telescopes ever made, and by a careful study of them I succeeded in making formulæ which readily give the dimensions of all the principal parts of an equatorial mounting of any possible size. The question which gave me most trouble was the determination of the proper thickness for the steel plates of the telescope tubes. No general integral can be found for the differential equations which express these thicknesses, and an expansion into series does not give sufficiently accurate results, but I finally succeeded in arranging a method by quadratures which is both simple and accurate. All the principal parts of our 12- and 26-inch equatorial mountings were designed in accordance with these formulæ, the special computations for the telescope tubes being in each case made by me, and copies of the formulæ were subsequently given to the contractors.

"Into both these mountings I have introduced one feature which I believe to be entirely new, namely, a pair of dials for indicating the right ascension and declination of the point in the heavens to which the telescope is directed. A dial indicating the right ascension has been used before, but so far as I know these telescopes are the first ever provided with declination dials. Heretofore the rough setting of large equatorials has usually been effected by means of coarsely divided circles situated, respectively, upon the polar and declination axes, but great difficulty is frequently experienced in seeing these circles at night, and in any event the hour angle of the object must be computed for setting in right ascension. With the new dials all these difficulties vanish. They face the observer when his hands are upon the right ascension and declination quick motions, they are brightly illuminated, they give the same degree of accuracy as the old-fashioned coarse circles, and as the right-ascension dial is moved by clockwork it shows the apparent right ascension of the telescope, together with its hour angle, and the right ascension of the meridian. Having the right ascension and declination of any visible object, the observer can instantly bring it into the field of the finder by setting these coördinates upon the dials; and if he wishes to set closer than that, as, for instance, in the case of a faint asteroid, he can readily do so, because the eyepieces of the microscopes for reading the fine right-ascension circle are situated at the sides of the dials, and the eyepieces of the microscopes for reading the fine-declination circle are close to the clamp and tangent screws at the eye end of the main telescope. All the movements of the instrument are controlled, and all the readings of the dials and circles are made, either from the floor of the dome or from the eye end of the main telescope, thus enabling an observer to work alone without the aid of an assistant. For greater convenience in observing the Sun and Moon, I have introduced supplementary gearing into the driving clock by means of which the speed of the telescope can be instantly changed from sidereal to mean solar or mean lunar. This gearing was specially computed by me, and is so exact that if the telescope is running truly on sidereal time, when changed to a mean solar or mean lunar rate, the errors are, respectively, only 0·80 of a second and 1·41 seconds per day.

"In planning the changes of the prime vertical instrument, my aim was to make the telescope perfectly symmetrical, and at the same time to preserve all the advantages for rapid handling which pertained to the old unsymmetrical form. This has been accomplished by giving the telescope the form of an ordinary transit instrument, and so arranging the reversing carriage that it remains permanently in place, with its machinery wholly beneath the floor. A crane and telescope have also been provided for manipulating the level. The result is that the instrument can be reversed in about fifteen seconds, and an observer standing outside of the northern pier can make all the reversals and readings of the level without moving from his place. The test of actual use has proved the new instrument to be very convenient, and it is hoped that it will give rather more accurate results than the old form.

"Before beginning to draw up the specifications for the new 6-inch transit circle, I made an exhaustive study of all the descriptions of such instruments contained in the library of the observatory, and I embodied the information so obtained in a series of formulæ for the determination of the sizes of all the principal parts of transit circles. The specifications for the new instrument are based upon these formulæ, supplemented by all the information which I was able to obtain from a careful examination of some of the best modern meridian circles."

WOLSINGHAM.—The very fine observing weather of last year caused the observations at Wolsingham to increase to such a number that it was necessary to stop observing in order to get the reductions up to date. Mr. Espin therefore in the summer took the opportunity of having his mirrors re-silvered, an operation which had not been done for some time.

The record of work for the year shows: (1) the detection of 489 stars with remarkable spectra, whose peculiarity had not been previously known; (2) the discovery of fifteen nebulous objects not contained in the New General Catalogue; (3) the detection of three new variable stars, and the confirmation of the variability of four others; (4) forty-eight plates taken with the 8-inch photo-telescope.

Five publications of work done in this Observatory have been issued during the year, in addition to the first volume of the new edition of 'Webb's Celestial Objects,' edited by Mr. Espin.

The Observatory sustained a severe loss early in the year by the death of Miss Brook, who was a liberal patroness of the Observatory and herself an observer.

PUBLICATIONS.

THE STORY OF THE SUN [*].—"All roads lead to Rome." The paraphrase of this remark applicable to Sir Robert Ball's books seems to be, all titles lead to geometrical astronomy, explanation of eclipses, Nova Aurigæ, variation of latitude, and Groombridge 1830. We expected after seeing the title that this large book was to be devoted to a history and account of the facts known of the physical constitution of the Sun, but not until Chapter VI., which gives an elementary description of spectroscopy with photographs of solar spectra, do we come to matter which is distinctly heliacal; the first five chapters might equally well have appeared, and they have appeared, in any book on astronomy. Chapters VIII., IX., and X. are wholly solar, giving respectively the facts known about Sun-spots, Prominences, and the Corona; but with reference to the first of these subjects we are of opinion that the statement on p. 148 as to the zones in which spots are seen is scarcely a good account of the phenomena. Prof. Ball gives a diagram of the Sun showing two zones, which exclude the equatorial belt, as showing the region in which spots are "particularly abundant," and says: "occasionally, especially in seasons of exceptional solar activity, these limits are considerably exceeded." In a book professing to give an account of solar phenomena we think that the variation of the position of the spotted area, with the variation of phase of the sun-spot cycle, which is one of the most remarkable features in Solar Astronomy, ought to have had more space devoted to it: may we call the author's attention to a diagram published in the 'Monthly Notices,' vol. l. p. 10, exhibiting the results of fourteen years' work at Greenwich, which shows, among other interesting things, that there are periods when one can predict with some confidence the appearance of spots on the solar equator. We may lay ourselves open to the charge of being prejudiced, but when we read on page 167 "our knowledge of Sun-spots in recent years is largely due to the extraordinary assiduity with which Signor Tacchini has studied them at the Collegio Romano," we, giving to Prof. Tacchini all the praise he deserves, cannot help asking why the almost complete record of sun-spots of the last twenty years made at the Royal Observatory should go with its merits unsung? Chapter XIV., on the Heat of the Sun, and Chapter XV., on the Importance of Carbon in the Sun, in which Dr. G. Johnstone Stoney's theory on the "Physical Constitution of the Sun" is given for the first time in a popular book, are the only chapters in which the constitution of the Sun is touched on; the remainder of the book leads us to stellar photography, stellar parallax, and Groombridge 1830. In fact the book is like others by Sir Robert Ball. And, while admitting the desirability of diffusing knowledge astronomical and otherwise, we are not sure that this is quite the sort of thing expected from a Lowndean Professor.

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[*] 'The Story of the Sun.' By Sir Robert Ball, LL.D., F.R.S. Cassell and Co., London, 1893. Price 21s.

NOTES.

Comet Notes.—Mr. C. L. Poor has contributed another paper to the 'Astronomical Journal' (No. 309) on Comet 1889 V. He finds that none of the four larger satellites of Jupiter can have sensibly affected its motion, but the fifth may have actually collided with it. He examines the effect of the ellipticity of Jupiter, and finds that in case of a very near approach it must be taken into account. The question of the identity of the comet with Lexell's cannot be finally settled till its return in 1896.

The Comet Rordame-Quénisset was seen at several observatories in November. The errors of Cerulli's ephemeris are about 1^s in R.A. and $10''$ in N.P.D., showing that his elements are very nearly correct. The comet will still be of about the 13th magnitude in February, and an ephemeris (for Berlin midnight) may be of use for the possessors of large instruments:—

	R.A.			S. Decl.			R.A.			S. Decl.	
1894.	h	m	s	°	′	1894.	h	m	s	°	′
Feb. 1....	11	44	49	4	46	Feb. 13....	11	22	13	6	42
5....		37	30	5	24	17....		14	26	7	20
9....		29	56	6	2						

The Astronomical Society of the Pacific have decided not to award the usual medal for this comet, in consequence of the large number of independent discoverers.

Dr. Kobold observed Swift's Comet (1892 I.) until 1893 Feb. 16, almost a year after its discovery. The places agreed closely with Dr. Berberich's orbit. Dr. Berberich finds evidence of pronounced personal equation in the observations of this comet, which he ascribes to the complicated structure of the head.

Brooks' Comet (*c* 1893) is beyond the reach of small instruments; we give, however, a rough ephemeris for the beginning of February:—

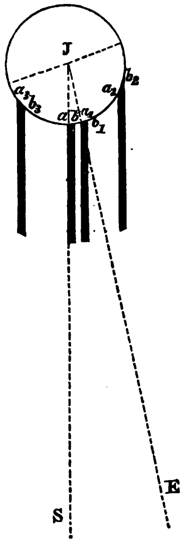
	R.A.			N. Decl.	
	h	m	s	°	′
Feb. 2	23	58	4	61	42
6	0	10	58	60	16
10	0	24	20	58	56

In the recent number of 'Publications of the Astronomical Society of the Pacific' there is a description by Prof. Campbell of the visible spectrum of this comet. Superposed on a feeble continuous spectrum there are five bright bands, of which three are the hydrocarbon bands seen in nearly all comets, but more sharply defined than usual. The other two are peculiar to this comet; one probably belongs to cyanogen and the other possibly to hydrogen. A. C. D. C.

Minor Planet Notes.—It has been decided to make the sequence of letters assigned provisionally to new planets continuous instead of beginning afresh each year. The following have been discovered in the last month, all by M. Charlois:—

AQ.... Jan. 8 AR.... Jan. 8 AS.... Jan. 10

We suggest the annexed diagram as explanatory of Prof. Schaeberle's geometrical theory of the apparent distortion of shadows of Jupiter's satellites referred to in our December number. Taking the plane of the paper as the plane of the ecliptic, and supposing Jupiter to be in that plane, let the circle represent the planet and the Sun be in direction JS. The broad lines represent the shadow-cone of a satellite as it crosses the disk. Obviously the length of the shadow on the planet varies in length, a_1b_1 and a_2b_2 being longer than ab, which we may call the normal length. Remembering that the shadows are seen projected at right angles to the line of sight, if the Earth be in direction JE, a_1b_1 at the centre of the disk will be seen of its natural length slightly greater than the normal, a_2b_2 will be contracted by projection less than it was previously increased, and will appear elongated, and a shadow a_3b_3 near the invisible terminator would be diminished by projection more than it had been previously increased, and hence would appear contracted. If, on the other hand, Jupiter be in opposition, that is, if the Earth be in direction JS, these shadows a_1b_1, a_2b_2, a_3b_3 projected at right angles to the line of sight will be seen of normal length. We thus have Prof. Schaeberle's conclusions; when the planet is in conjunction or opposition there are no appreciable geometrical distortions. In other positions the shadow of a satellite is elongated when near the visible



terminator, and contracted when near the invisible terminator *. The distortion is practically zero when near the centre of the disk.

UNIVERSAL TIME.—Two more Continental countries have recently taken steps to alter their system of time-reckoning in accordance with the movement that is so fast progressing. Since the first day of this year, mid-European time, one hour fast on Greenwich, has been used as the legal time and for every-day purposes throughout Denmark; and a legal enactment authorizes the use of the same time-reckoning in Switzerland from the 1st of June next. Thus at the present moment the time-systems of more than half of the countries of Europe (if we include Norway and Sweden, whose time differs very slightly from mid-European) depend on the Greenwich meridian. And while foreign countries are thus using the Greenwich meridian for their systems, it is curious to note that in an island adjacent to England, and which is still under British rule, the time used should be that of a meridian not Greenwich.

WE are accustomed to the exactness of Tennyson's *science*, and the following may be interesting as bearing this truthfulness out in a very striking manner. A correspondent, when reading 'Maud' recently, was much struck with the passage where Tennyson speaks of the month when the daffodil dies and the Charioteer and the Gemini hang over Orion's grave.

He remarks:—"I imagine the poet refers to the months of April and May; and on the next page he speaks of Mars like a ruddy shield on the Lion's breast. The whole passage refers to the Crimean War, which was from 1854 to 1856. It would interest me to find the exact date of writing from internal evidence, if it can be fixed, or to see whether he has made the same slip that painters make—little thinking of detection—when they paint a rainbow over a cathedral right in the southern sky."

We find that Orion sets at about 11^h sidereal time, *i. e.* at

11 P.M., March 21,
9 „ April 21,
7 P.M., May 21.

and Mars was in Leo in

1852 in June,
1853 in November,
1854 in April and May,
1855 in October,
1856 not at all.

Now as between 1852 (which is just possible) and 1854 we have the additional fact that Mars was a long time in Leo in 1854, and went at a good pace through it in 1852. It was, in fact, for nearly a whole month just in that position in which Tennyson describes it, "like a ruddy shield on the Lion's breast," *i. e.* between α and γ Leonis.

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* Treated in this approximate way, the length of a shadow as seen would be given by the formula $ab \cos EJ\sigma / \cos SJ\sigma$ (σ being the position of shadow on disk). SJE can never be greater than 12°, in which case if $EJ\sigma = 70^\circ$ (on the side towards a_2b_2), the shadow would be increased in the ratio 1 : 2·45.

THE WEATHER IN JANUARY.—The past month has been somewhat exceptional as regards extremes of temperature. During the first week very low temperatures prevailed, the mean temperature for the days Jan. 4, 5, and 7 being respectively 16°·7, 22°·4, and 17°·3 below the average of the fifty years' record, 1841–90, for these dates. The maximum temperature on Jan. 5 was only 19°·0 and the minimum 12°·8. Since these dates the temperature has been almost consistently above the average, the mean excess from Jan. 10 to the end of the month being 5°. The rainfall has been somewhat excessive, as the total 3 inches for 21 days is an inch above the average for the corresponding dates. The high barometer at the end of December and beginning of January (it rose to 30·56 inches on Dec. 29) recalls to mind the story of an observer of the very high barometer readings of January 1882, who, when he found the barometer in his study was not likely to touch the 31-inch mark as he was anxiously hoping, took it downstairs to the kitchen, where the altered conditions of temperature and altitude had the desired effect, so it is said.

WE regret to have to announce the death of Herr von Freeden, who died recently at Bonn. The deceased gentleman, who was born at Hanover in 1822, devoted his life to the sciences of nautical astronomy and navigation. He filled successively the posts of headmaster and rector of the Navigation School at Elsfleth, and after having taken an active part in the foundation of the German "Lloyds" he established and directed the German Maritime Observatory at Hamburg. He resigned the direction of this Observatory in 1876, when it was taken over by the German Admiralty; and has since edited the 'Hasna,' a periodical dealing with maritime affairs.

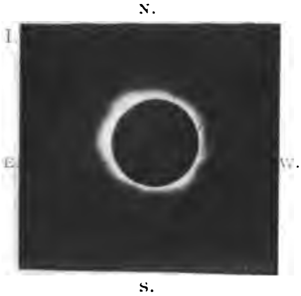
We are asked to make the following announcement:—Among the books which Mr. Barclay presented to the Liverpool Observatory are several copies of vols. i., iii., and iv. of the Leyton Observations. It is proposed to give these duplicate copies to any Observatory whose library may be deficient of these volumes. Application should be made to the Director of the Bidston Observatory, Liverpool.

OWING to the impending removal of Prof. H. H. Turner to Oxford, may we ask Subscribers to make Cheques and Postal Orders payable to H. P. Hollis, and address to the Royal Observatory, Greenwich, which will still remain the head-quarters of the Magazine.

MANY congratulations to Prof. J. Norman-Lockyer, F.R.S., C.B., on his new honours; and may we be permitted to offer the same to Mr. Preece, F.R.S., C.B., a worker in another branch of science, but connected to some extent with Astronomy.

WE were sorry to find that an error had crept into the 'Companion' for 1894. We correct it in the leaflet sent out with this Number.

I.



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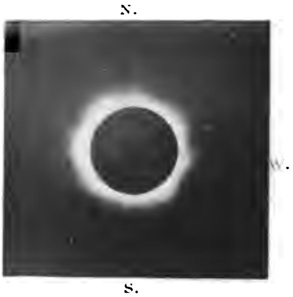

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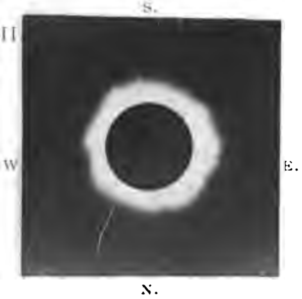

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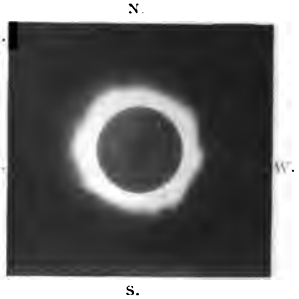

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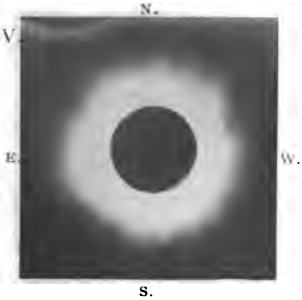

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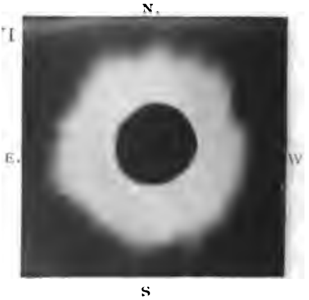

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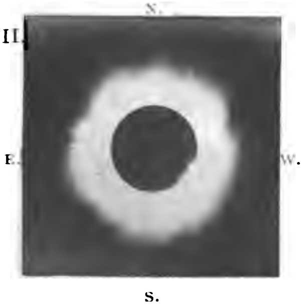

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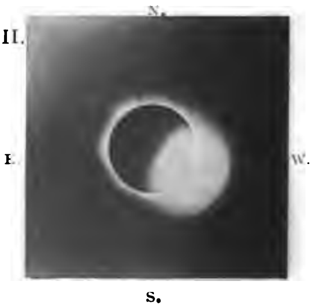
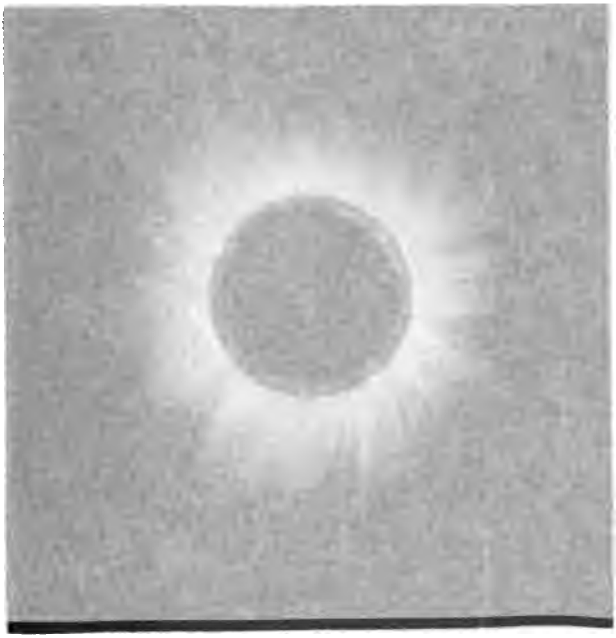


Photographs of the Solar Corona during the Total Solar Eclipse of 1893, April 16, taken in Chili, by the Members of the Lick Observatory Expedition.

The lower edges of the plates are parallel to the celestial equator.

he sun's axis is represented by lines through the centres of the plates, cutting he circumference at points about 26° to the West of the North point.



TOTAL ECLIPSE OF THE SUN, 1882, May 16.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 212. MARCH. 1894.

ANNIVERSARY MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, February 9, 1894.

Capt. Abney, C.B.., F.R.S., *President*, in the Chair.

Secretaries: Prof. H. H. Turner, M.A., B.Sc., and
E. W. Maunder.

Mr. Maunder read the Minutes of the last Anniversary Meeting, which were confirmed.

Mr. Inwards read the Auditors' Report, which stated that they had examined the Treasurer's accounts for the year 1893 and found and certified the same to be correct. The cash in hand on Dec. 30, 1893, amounted to £376 19*s*. 6*d*. The books and vouchers were examined and found to be satisfactory.

The Secretaries read extracts from the seventy-fourth Annual Report of the Council. The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—Rev. D. Ace, J. D. Allcroft, C. Barton, V. Fasel, A. E. Nevins, F. H. S. Orpen, Maj.-Gen. H. S. Palmer, Rev. C. Pritchard, W. S. B. Woolhouse; and Associates Rudolf Wolf and Baron Fabian J. Wrede.

The President. The Council have awarded the Society's Gold Medal to *Mr. S. W. Burnham* for his discoveries and observations of Double Stars.

The President having delivered his address, laying before the Society the grounds on which the award has been founded, handed the Medal to Dr. Huggins, the Foreign Secretary, for transmission to Mr. Burnham.

Mr. Knott moved:—"That the Report now read be received and adopted, and be printed and circulated in the usual manner, together with the Report of the Auditors and the President's Address."

Mr. G. Hunt seconded the resolution, which was carried.

The President. The next business will be the Ballot for Officers and Council. It is my duty to appoint Scrutineers. I will ask Mr. Inwards and Mr. Woodd-Smith to act as Scrutineers on this occasion. The Ballot will now be taken.

Mr. Ranyard. I beg to move that the Ballot be kept open for 10 minutes.

Mr. R. C. Johnson seconded.

Dr. A. A. Common. I should like to move that the Ballot be kept open till the business be done.

The President. You will keep the Scrutineers the whole of the time. If you have got an amendment I will put it; otherwise I will put the resolution: "That the Ballot be kept open till 10 minutes past 4 o'clock."

The motion was carried, and the Ballot was then taken.

The President. There is notice of a motion, "That henceforth the Meetings of the Society be held at 4.30 P.M., and that Bye-Law 44 be altered accordingly." I will ask the Secretaries to read an account of the action that has been taken from time to time.

Prof. Turner. In 1885 it was proposed to substitute "17 hours" for "8 o'clock." Postcards were sent to all the Fellows asking for their opinion as to the hour most suitable for meeting. The result was reported at the May meeting—106 for 8 o'clock, 125 for 5 o'clock, 150 neutral. It was then proposed that the meetings be at 5 o'clock, but that was negatived. In 1890, Mr. Brett proposed to meet at 4 o'clock instead of 8, and it was proposed and carried to substitute 5 for 4 o'clock. The motion was put to the Annual Meeting in February, with the amendment of 5 for 4 o'clock, and Mr. Newbegin proposed that the matter be deferred, which was carried. The proposal was then discussed in March, but deferred to the next meeting. In April it was proposed that the Ordinary Meeting be not earlier than 4.30. The Council were of opinion that there would not be time for their business, but did not express definitely their opinion as to any change. At the meeting in November another notice of motion for meeting earlier than 8 o'clock was received, and it was put to a Special General Meeting in December 1890. Then the motion was originally 4 o'clock, and was amended to 5 o'clock, but the amendment was negatived when put to the Meeting. In January 1891 a notice of motion was read that henceforth the meetings be held at 5, and was proposed at the Annual General Meeting in February. An amendment to omit the word "five" and substitute "alternate months five and eight" was lost. So also was the original motion for 5 P.M. Generally speaking it may be said that the proposal was made in 1885 and was tested by reply postcards, causing a Special General Meeting to negative the change. Again in 1890 the motion was lost by a small majority, and in 1891 the motion was also lost, but the figures are not given.

A Fellow. May I ask the Secretary to read Bye-Law 44, to see where we stand exactly?

Prof. Turner read the Bye-Law.

The President. I would just point out that the new situation is this, that the Council thought they would not be able to get through their business in time if the Ordinary Meeting was held at 4.30. The Council now think they can get through their business in time. They express no opinion, but simply say their convenience is not concerned.

Mr. Waters. I have been asked to propose this resolution in the absence of Mr. Chambers, who is unavoidably prevented from being present, and I have much pleasure in doing so, as I originally proposed this change, and I think that since 1885, when this was originally suggested, the reasons have, if possible, become stronger than they were then for the alteration suggested. I do not propose to detain you with a recapitulation of all the arguments from time to time made in favour of this alteration, inasmuch as I have only just this moment been asked to propose this resolution. It is really a matter for the consideration of each Fellow, as to which is more convenient for himself, and which plan is better for the Society. I hold a strong opinion that the afternoon would be preferable, and that we should secure a larger attendance. I therefore propose that the Meetings be at 4.30 P.M., and that Bye-Law 44 be altered accordingly.

Dr. Common. I second it. We have had the arguments before us, and it must be settled by each man's convenience. We must not forget that this motion would have been carried, I believe, a year or two ago, had it not been for the very earnest appeal of Mr. Knobel, who was then Secretary, that the Council could not get through its work in time. He ventured to make an appeal that it would not be right to carry this motion. Now we have it from the lips of the President that the Council itself is actually ready to accept the change that the hour of Meeting be altered to 4.30. It would be a change beneficial both to the Fellows and the Society.

Mr. Ranyard. This becomes what my friend Capt. Noble would call a "hardy annual," but it seems to me that it should not be settled at an afternoon meeting composed of gentlemen to whom the afternoon is certainly a convenient time. I notice there are very different faces here at the afternoon meeting from those we see regularly at the evening meetings, and it seems to me if this meeting were to come to the conclusion that the afternoon would be more convenient, it would be only fair to give the other Fellows an opportunity of voting. I think it is a matter for the welfare of astronomy and of the Society as a whole. I cannot help thinking that the after-talks we get at the evening meetings are a very important element. If we had afternoon meetings most of us would be rushing off to our dinners, and there would not be the opportunity of making new friends. For that reason I should certainly vote for the evening meetings.

Mr. Gregory. I only propose to say a few words upon the motion. In the first place, one of the chief arguments by the proposers of this change is drawn from a comparison with the meetings of the Royal Society; but the constitution of the Royal Society is so different from the constitution of our Society or any other learned Society in London that the analogy is a false one. The Royal Society consists largely of people who are independent of time, and on whose hands time hangs heavily perhaps. They can just as well attend the afternoon meetings as the evening meetings. But in our Society the majority of us are engaged during the day, and we find it more convenient to attend in the evening than in the afternoon. Another argument is that we should get country members by holding the meetings in the afternoon. If that were true and we could get country Fellows, by all means make the change; but there are many reasons for doubting the success anticipated. I had the honour for several years of attending the meetings of the Royal Society, and I have no hesitation in saying that the country Fellows are in a very small minority at all the meetings. The majority who attend those meetings are town and not country Fellows. That goes to show that we cannot depend on country Fellows to make up for the falling-off of London Fellows in the afternoon. At present we always have a full attendance and very successful meetings, and yet we are asked to change the time. There is one other point I should like to mention, and that is with regard to the time of the meetings of other Societies. Of all the Societies in Burlington House, none, with the exception of the Royal Society, meet in the afternoon. There are the Chemical and the Geological Societies and others, and with the exception of the Royal and Physical Societies, all meet in the evening. That shows you have the survival of 8 o'clock as the fittest time. I saw Prof. Boys at South Kensington yesterday, and he mentioned to me a point which I think ought to weigh considerably with this Society—that is, that the Physical Society took into consideration the meetings of the Astronomical Society when arranging the present hour and day of meeting, and by changing our time to 5 o'clock we clash with them. I really consider that is sufficient to show it is not really a personal matter, but a matter which one has to consider in relation to other Societies in London.

Mr. Milligan. We see different faces here in the evening to those we see in the afternoon, and I doubt very much whether the proposed change would be for the future welfare of the Royal Astronomical Society. I think that is the main point at issue. After some thirty years' experience in attending and organizing meetings, many of which have been in London and the suburbs, and in connection with Societies for the consideration of subject-matter just as dear to them as Astronomy is to the Royal Astronomical Society, I have no hesitation in saying that it would be a great mistake to alter the meetings of this Society to the afternoon, and I am afraid it would be a matter of disappointment and failure.

Admiral Ommanney. I am one of the oldest members of this Society, and I hope I have the welfare of the Society at heart no less than everybody else. My experience is, it would be attended with the greatest benefit to the Society to meet in the afternoon. There are a great many old men here. I do not come under the denomination of a man of business, but I am a man of work, and it is difficult to get home and get back here by 8 o'clock. I think I should be much more interested by coming before dinner, before I am tired. I have also at heart the welfare of those who reside at long distances. People who live at Greenwich and other parts would find it much more convenient for them to meet in the afternoon than in the evening.

Mr. Woodd-Smith. Of course those who find it convenient to attend this meeting prefer the afternoon; would it not be possible to have another decision on the subject, and to have another issue of postcards, by which every member should express an opinion? It is, after all, a personal matter, but the difficulty is to find out exactly what every Fellow prefers. I should propose that another ballot be taken by postcards.

Dr. Kinns seconded the proposal.

Dr. Common. The result on the last occasion was very unsatisfactory, owing to the large number of neutrals.

The President. I doubt whether the proposal is in order. It is hardly an amendment to the resolution before us.

A Fellow. I should like to ask, in the case of this resolution being passed at this meeting, would it require to be confirmed at any future meeting or not?

Mr. Kennedy. I would suggest whether the advantage of all persons would not be met by having it at 5.30? As a man of business I had to give up my own important appointments to come here; but if the time were 5 or 5.30 all men of business might come here. Otherwise, 8 o'clock would suit me better, although it entails my being home at 1 o'clock in the morning.

Mr. Knott. I would ask as to the experience of the British Astronomical Association. Is there a good attendance there?

Capt. Noble. Having sat as President of the British Astronomical Association in Barnard's Inn, I have more than once seen the room there so crowded that people were standing against the wall, absolutely incapable of getting seats; and it must be borne in mind that at the British Astronomical Association we address a rather lower stratum than at the Royal Astronomical Society. I do not mean they are all of one social rank, because that is not the fact: we have them of all social ranks; but, not to use the word offensively, they are more of a mixed lot than the Royal Astronomical Society; but I do think this, that if we can get persons in the social position of many members of the British Astronomical Association to meet at 5 o'clock in the afternoon, *à fortiori* persons in a higher social rank should not find even so much difficulty as they do in being present. I am bound to say that we have ladies and gentlemen in nearly every social rank. This Society is established for the promotion and encouragement of Astronomy; and for whatever promotes Astronomy the discomfort of the individual must go to the wall, if he has the good of the Society at heart.

Mr. Maunder. About the British Astronomical Association I can of course fully confirm what Captain Noble has said with regard to our crowded meetings at Barnard's Inn; but we have experienced one or two difficulties in consequence of our meetings being at 5 o'clock. The first is, it has been difficult to get through our work at the Council. The next is, we have lost the services of two or three valuable men at the Council who could not come sufficiently early. A third drawback has been that about half-past six the meeting practically breaks up. Another thing is that though very frequently we had the room as fully packed as it could hold, yet Barnard's Inn is in the City, and business men came there straight from business. We removed to University College, and our attandance has decidedly diminished. Since Burlington House is still further from the City, the probability is that we should find a smaller percentage come up here from the City than we find do so at University College.

Dr. Johnstone Stoney. I was rather disappointed to hear of the circumstance that a great number of postcards stood neutral on the former occasion. The reason I stood neutral was that at that time I lived in Ireland, at so great a distance that I could not attend the meetings, and I thought the question was exclusively for those who might be able to attend. If, therefore, you send out postcards, I think it desirable to limit them to those members of the Society who are resident in London, or at such a moderate distance that they can attend. I think it might perhaps be well not to commit ourselves unnecessarily to a final division. I think it desirable that the proposal put to the Meeting should be that the Meetings for the rest of this Session should be at 4.30; and at the commencement of next Session or the end of this, we should be certainly in a position to know which arrangement is best for the Society. Though some of the Fellows are disposed to speak strongly as to the bad effect on the Society of the change, it is quite plain that that must be conjecture in the present state of things.

The President. The following amendment has been handed in: "The Council are requested within the next eight weeks to send reply postcards in which to ask whether the Fellows receiving the same are in favour of altering the hour from 8 to 4.30." That is proposed by Mr. Woodd-Smith, seconded by Dr. Kinns.

Mr. Ranyard. I wish to speak against the amendment. It seems to me inadvisable that we should at this time agree to that modification. I think we had better vote on the question so frequently put before us; and if any change is decided upon we can demand a poll, or a poll by postcard.

The President. In the Bye-Laws I do not see anything about a poll.

Mr. Ranyard. Is it not a common right of all public meetings to demand a poll? I think you may always appeal to the general body. It seems a matter of actual fairness to those who are not present. Those who wish to have a vote taken at this meeting would be wiser to vote against this amendment, or take the opinion of the Fellows as to what course is advisable.

Prof. Turner. Personally I feel very strongly opposed to the course suggested by Mr. Woodd-Smith. It seems to me to encourage the idea that the Annual General Meeting of this Society is not competent to transact its business. I would very strongly protest against taking a poll by postcards, which would be treated later at a meeting which would not be a General Meeting of the Society. Such a course would be inferior in every way to allowing the Society to follow its own Bye-Laws and transact its business at the Annual General Meeting.

Mr. Seward. Can we not arrange for this resolution to be put, first, to an afternoon meeting, and then to an evening meeting? It seems to me Mr. Ranyard raised a very important point when he said this is an afternoon meeting, and those members who can, as a rule, attend only in the evening are not present. We are only representative of that section of the Society which can meet at 4.30. We do not represent in any way the 8 o'clock section.

The President. What you suggest is not in our power. There has been notice sent round to every Fellow of the Society that certain business is going to be transacted at the Annual General Meeting. If the Fellows wish to record their votes for any motion, or if they object to any course that is proposed to be taken, now is their time. I am afraid the suggestion would be *ultra vires* entirely.

Mr. Woodd-Smith. I am quite in the hands of the Society. I will withdraw my proposal with pleasure. I do not think it is acceptable.

Dr. Kinns. I withdraw it too.

The President. Now the main question is before the Meeting. You have all made up your minds. If you discuss it till doomsday you will not change. Therefore I put it to the Meeting: "That henceforth the Meetings of the Society be held at 4.30 P.M., and that Bye-Law 44 be altered accordingly."

The motion was negatived by 39 to 23.

The following gentlemen were elected as Officers of the Society for the ensuing year:—

President: Capt. W. de W. Abney. *Vice-Presidents*: Dr. A. M. W. Downing, Dr. J. W. L. Glaisher, Mr. E. B. Knobel, and Mr. E. J. Stone. *Treasurer*: Dr. A. A. Common. *Secretaries*: Mr. E. W. Maunder and Prof. H. H. Turner. *Foreign Secretary*:

Dr. W. Huggins. *Council*: Mr. W. H. M. Christie (Astronomer Royal), Mr. Frank McClean, Mr. W. H. Maw, Mr. H. F. Newall, Capt. William Noble, Mr. A. Cowper Ranyard, Dr. Isaac Roberts, Mr. G. M. Seabroke, Rev. Walter Sidgreaves, Dr. E. J. Spitta, Dr. G. Johnstone Stoney, and Lieut.-Gen. J. F. Tennant.

Col. Burton-Brown moved, and *Admiral Ommanney* seconded: "That the thanks of the Meeting be given to the Vice-Presidents and other members of the Council who now retire."

The motion was carried.

Dr. Bryant proposed, and *Dr. Kinns* seconded, a "vote of thanks to the Scrutineers of the Ballot and the Auditors for their services."

The motion was carried.

The following gentleman was elected a Fellow of the Society:—

Wm. F. Stanley, *F.G.S.*, *F.R.Met.Soc.*, Cumberlow, South Norwood, S.E.

The following gentlemen were proposed for election:—

Lyndon Bolton, *B.A.*, Patent Office, W.C. (proposed by H. Seward); *F. W. Dyson*, Fellow of Trinity College, Cambridge (proposed by H. H. Turner); *G. P. Jenkins*, National Provincial Bank, Llangefni, Anglesea (proposed by G. H. With); *W. Redfern Kelly*, *Mem.Inst.C.E.*, Dalriada, Malone Park, Belfast (proposed by Major S. H. Maxwell).

ROYAL METEOROLOGICAL SOCIETY.

The monthly meeting of this Society was held on Wednesday evening, Feb. 21, at the Institution of Civil Engineers, Westminster, Mr. R. Inwards, F.R.A.S., President, in the Chair.

Mr. R. M. Barrington, M.A., LL.B., Mr. C. G. L. Cator, and Mr. H. Owen were elected Fellows of the Society.

The following papers were read:—

1. "Temperature, Rainfall, and Sunshine at Las Palmas, Grand Canary," by Dr. J. Cleasby Taylor. The author gave the results of his observations during the five years 1889–93. The island of Grand Canary occupies a position midway between the African continent and the most western of the Canary group. The mountain-peaks rise to a little over 6000 feet, and are about 20 miles from the coast. The chief town and port of the island, Las Palmas, is consequently free from the influence of the mountains. The diurnal range of temperature fluctuates considerably with the variations in wind and sunshine. With a southerly wind (which usually dies down at sunset) the range is increased, but the greater part of the increase is due to a higher day-temperature. With northerly winds persisting after sunset, the range may be

very slight, particularly if the day has been cloudy. The sea temperature is dependent on causes outside the limits of the archipelago; local presence or absence of sunshine does not cause any difference. A boisterous northerly wind, with a high sea, may cause the temperature to fall quicker than usual, or, if the temperature is rising, to check the rise, but any sudden variation is very rare. The rainfall is not great, though it is spread over a large number of days, the average yearly amount being 8·90 inches. The greater part of the rain falls during October to January, while the period from June to September is practically rainless.

2. "Report on the Phenological Observations for 1893," by Mr. E. Mawley, F.R.Met.Soc. This is a discussion of the observations made on the flowering of plants, appearance of insects, and the song and nesting of birds. The year 1893 was in complete contrast to its predecessor, being very forward throughout the United Kingdom. The February and March plants were later than usual in blossoming, especially in the colder parts of our Islands, but after this the dates were everywhere in advance of the average, and during the height of the flowering season the departures from the mean were often considerable.

3. "Comparative Observations with two Thermometer-Screens at Ilfracombe," by Mr. W. Marriott, F.R.Met.Soc. Some exception having been taken to the thermometer-screen which has been in use at Ilfracombe for a number of years past, a Stevenson screen was placed at a distance of 60 feet from the old screen in October 1892, since which date simultaneous observations in the two screens have been made daily at 9 A.M. The results of this comparison show that the temperature deduced from the two sets of observations agrees very closely, the old screen being only 0°·3 higher than the Stevenson.

BRITISH ASTRONOMICAL ASSOCIATION.

The third ordinary Meeting of the present Session of the above Association was held on Jan. 31, at University College, Gower Street, the President, Dr. A. M. W. Downing, M.A., F.R.A.S., in the Chair.

The election by the Council of 15 new Members was confirmed by the Meeting, and the names of 13 candidates for membership were passed for suspension.

Mr. G. J. Newbegin read a paper on his observations of "Solar Prominences in 1893," with special reference to seven prominences which he thought were of sufficient interest to be exhibited to the Association by means of lantern-slide reproductions of his drawings. The paper was illustrated by the exhibition of the slides referred to. In reply to a question from *Mr. Evershed*, *Mr. Newbegin* stated that he had seen no reversals of any metallic lines on any of these prominences.

Miss Everett then read a couple of papers by the *Rev. W. R. Waugh*, the one a "Note on Venus," the other on "Prof. Barnard's Solution of the Apparent Duplicity of the First Satellite of Jupiter." In the former Mr. Waugh urged the formation of a Section for the observation of Venus, a suggestion the *President* warmly supported. *Mr. Holmes* commenting on the *lumière cendrée* observed on Venus showed that it could not possibly be due to Earth shine.

Mr. G. M. Seabroke delivered a lecture on a "Method of Graphically constructing the Apparent Orbit of a Binary Star." The lecturer's purpose was not to lay any new method before the Members, but to explain the method in ordinary use, in the hope that some of the younger Members might be induced to take up this branch of work.

Mr. Duke read some notes which he had made on "The Best Use to Make of Small Apertures," advocating the use of a light in the observatory under certain circumstances. *Messrs. Davis, Maunder, Chambers,* and *Newbegin* commented on the paper, dwelling especially on the need for proper preparation of the eye before attempting the observation of faint objects.

Miss Everett read the Report of the Meteoric Section, and the *President* announced that the Council had taken the first step towards obtaining the use of a library for the Members of the Association. The authorities of University College had kindly allowed them to place a bookcase in the anteroom of the room in which the meetings were held, and the Council had sanctioned the necessary expense for purchasing and fitting-up a bookcase. The books in their possession would be placed in the bookcase, and it would be open to Members on the afternoon of the Meeting.

The Meeting adjourned at 6.40 P.M.

The Announcement of Discoveries.

ON the evening of Sunday, Feb. 18, the following telegram was received at the Royal Observatory, Greenwich:—

"Look five minutes north Juipeter five and ten minutes following." (Handed in 7.20 P.M.)

The name of the sender, a well-known name in the astronomical world, is suppressed for reasons which will become obvious. The moral to be pointed in the present note is not aimed at an individual.

It was a fine night, the first for some time. Being Sunday night, the observing staff was reduced to a minimum. But the adjustment of the 28-inch equatorial, and the determination of the proper separation of the lenses for photographic and visual work, are at the present time imperatively demanding that no opportunity be neglected; and being the first opportunity after several cloudy nights, Mr. Lewis was up early to make the next experiments on the programme. The Astronomer Royal, who has scarcely been away from the observatory for six months, had just returned from a well-earned two days' holiday; and the chief assistant had come up to report to him about the explosion in the Park, and consult about measures to be taken in consequence. On receipt of the telegram only one course was possible. The whole of the available strength was called out to see what the telegram might mean. Instruments of all kinds, from an opera-glass to the 28-inch, were turned upon the region indicated, but without result. Maps were consulted to see if nebulæ or other objects in the vicinity might have been mistaken by the sender of the telegram for something new. The telegram itself was read and re-read. It is reproduced above *literatim*, including the misspelling of Jupiter; and to the phrase "five and ten minutes following" was assigned every possible meaning, including $5^{\circ}\ 10'$, the signification $5^{h}\ 10^{m}$ only being excluded as palpably absurd. Even the Morse Code was consulted to see if the aforesaid misspelling Juipeter might mean anything. Total result: nothing found, and a *fine* night wasted for several people and a whole observatory.

Next morning the following postcards were received:—

"Feb. 18, 1894, 6.45 P.M.

"DEAR SIR,—There appear to me to be two cometary bodies 5′ N. Jupiter and 5′ and 10′ following. I do not know of any nebulæ just there. Diffuse no sharp nucleus considerable size."

"Feb. 18, 1894, 7.45.

"DEAR SIR,—I fear my telegram and P.C. is only a false alarm, as I can now see nothing of the nebulosities. The curious thing is they were distinctly seen by four persons. I hope I have not caused any waste of time. The appearance persisted until 7.30."

The above facts might almost be left to speak for themselves; but we will venture to put into words what would probably be the mental comments of those sufficiently familiar with practical astronomy.

(1) There is no question about the *bona fides* of the sender of the telegram or his care in observation. His ability we might make clear to our readers by mentioning his name, but to cause him this additional mortification would not only be cruel, but quite foreign to our present purpose, which is to lay emphasis on point (2) entirely. To say that his name was sufficiently well known for the telegram to receive the attention above mentioned is perhaps enough. His care in observation and *bona fides* are made clear by the postcard next morning. He had apparently called in three or four other witnesses, and not despatched the telegram until he had watched the supposed objects for some time.

(2) But we wish to ask, and to ask emphatically, whether he was not guilty of negligence, even gross negligence, in the announcement of his discovery? The direction "look" is in itself

sufficient to condemn him. In these hard times one is apt to condense a telegram when possible; but the saving of a few pence when the discovery of a comet, and a double comet, is in question, is an economy of which the perpetrator ought to have been ashamed even if it had by good fortune not led to any misunderstanding. The telegram is only intelligible by help of the subsequent postcards. If both the postcards had been telegraphed verbatim the expense would have been less than five shillings. The cost of a fine night at the Greenwich Observatory can scarcely be estimated at less than fifty pounds.

We think it well that such facts as these should occasionally be brought prominently and emphatically before the astronomical world. It is easy enough to blame others for not having paid sufficient attention to announcements; it is not so easy to judge when to follow up a vague, clumsy, indication of discovery, often without any sort of credentials from the sender—which *might*, however, be on the right lines,—and when to neglect it. It need scarcely be said that nine out of ten such announcements are worthless; and the tenth often seems like unto them, owing to want of care on the part of the sender. If there were nothing to do at the Royal Observatory and other observatories but to await such announcements and test them, one might forgive a little vagueness in a telegram, which would perhaps provide a little healthy exercise for the unemployed in making out its meaning. But when there is more to do than one can quite manage, when the Director has to exercise self-restraint in not taking up new lines of work which the progress of astronomy might seem to demand in order to carry out efficiently the researches on hand, then one grudges not a little the time and energy wasted on a mare's-nest.

To conclude with a few

GENTLE HINTS TO DISCOVERERS.

(1) In announcing a discovery, in the name of a Fine Night do not be vague; spend all your spare coppers in extra words.

(2) Never under any circumstances say "Look." You may wish to get independent confirmation, but you can probably get that at your own telescope by calling in one of your friends: in your telegram say what you think you have found, and even describe it minutely.

(3) If your name is not well known, give in the telegram some information as to your experience, mentioning even what catalogues of strange objects you have consulted.

By attention to these precepts you will probably escape objurgation, even if your conjecture should not be confirmed; while a studious neglect of them will perhaps result in your finding that those to whom you announce something new will claim to have rediscovered it.

Ten Miles above the Earth.

An article under the above title, by Prof. H. A. Hazen, in the 'American Meteorological Journal,' describes the ascent of a balloon from Paris called 'l'Aérophile,' designed to reach an extraordinary height, and gives the meteorological phenomena observed. As the temperature of the various strata of the atmosphere surrounding the Earth enters largely into the question of astronomical refraction, the following table seems sufficiently interesting to be copied here:—

"RÉSUMÉ OF OBSERVATIONS OF THE ASCENSION OF 'L'AÉROPHILE,' MARCH 21, 1893.

Civil Time.	Barograph pressure. Inches.	Height not corrected for temperature. Feet.	Temperature. Degrees Fahr.	Vertical velocity. Feet per second.	Decrease of temp. with height. 1° in
h m					
12.25	29·7	213	63		
·30	21·6	8,530	39	28·2	350 ft.
·35	15·8	16,730	14	27·2	337
·40	12·0	23,950	−11	24·6	321
·45	8·5	33,000	−40	30·2	318
·50	6·3	40,910	−60	26·4	
·55	5·2	45,930	−55	16·7	
·57	....	....	−52		
14.30	4·06	52,500	[−104]	....	[313]
15.15	4·1	52,280			
16.5	....	50,850	− 6		
17.11	4·7	48,560	−10		
·21	....	....	−20		
·31	....	....	−21		
·41	....	....	−28		
·51	7·1	....	−36		
·55	....	37,730	−41		
18.1	....	....	−44		
·11	9·1	31,170	−53	....	299
·21	....	....	−40		
·31	....	....	−15		
·41	....	....	7		
·43	18·8	12,140	9		
·45	19·5	11,160	14	8·2	301
·50	21·3	8,860	19	7·5	275
·55	23·1	6,730	27	7·1	278
19.00	24·8	4,920	31	6·0	242
·5	26·7	3,020	38	6·2	224
·11	29·53	328	50	7·5	

"The balloon landed at Chanveres near Joigny, having been afloat six and three-quarters hours. It is noted by M. Hermite that probably during the most rapid rise and fall there was sufficient ventilation to give fairly accurate temperatures, but at the highest part of the trip the air was so stagnant and the solar radiation so great that the temperature was entirely erroneous.

"This view must be accepted with caution, however, for at 12.55 with the velocity of 16·7 feet per second the temperature began to rise. This remarkable rise of 5° at a velocity of 16·5 feet is attributed by M. Hermite to the influence of solar radiation, but it is doubtful if that is the whole explanation."

On the Visual Appearance of Nova Aurigæ[*].

SOME discussion has taken place as to the visual appearance of this object since it was re-observed in the autumn of 1892. At the Lick Observatory and also at Pulkowa the Nova was seen to differ in appearance from a star of similar magnitude, and to have taken on the appearance of a small bright nebula consisting of a nucleus surrounded with a pretty bright and dense nebulosity 3″ in diameter (A. N. 3118, p. 408, and 3184, p. 263).

Mr. Newall, on the contrary, observing with the 25-inch Newall refractor at Cambridge on 1892 Sept. 14, says:—"With a power of 215 I, at first, thought that the Nova was diffuse and resembled a planetary nebula rather than a star; but on focussing more carefully I made out that the Nova was distinctly stellar; now, however, the neighbouring stars resembled planetary nebulæ. In fact the Nova and neighbouring stars could not be focussed simultaneously. The Nova owes its visual magnitude nearly entirely to the light that gives rise to the three green lines, and it was possible to verify a conclusion drawn from this fact and from the nature of the chromatic dispersion of a refractor 29 feet focal length; the image of the Nova was distinctly more point-like than that of the neighbouring bright star when each in turn was focussed as carefully as possible" ('Nature,' vol. 46, p. 489).

Dr. Roberts photographed the star on 1892 Oct. 3 with an exposure of 110 minutes, and on 1892 Dec. 25 with an exposure of 20 minutes, the diameters of the photo-images being 21″ and 13″ respectively. Dr. Roberts concludes—"there is no indication of nebulosity round the Nova or in its vicinity; it appears as sharply defined as the other stars" ('Monthly Notices,' vol. liii. p. 123).

Professor Vogel still maintains (A. N. 3198, p. 76), as an explanation of the nebulous appearance seen at the Lick Observatory and at Pulkowa, the view which he suggested in his paper "Ueber

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[*] From 'Astronomische Nachrichten,' No. 3211.

den neuen Stern im Fuhrmann" (Abhandl. d. Kgl. Akad. d. Wissensch. Berlin, 1893, p. 46): "dass die beobachteten Hüllen um den Stern nichts anderes als die chromatischen Abweichungskreise gewesen sind."

It may therefore be of interest for me to state the results of a careful scrutiny of the image of the Nova in a reflecting telescope which gives very fine definition. This telescope has an aperture of 18 inches, with both mirrors of speculum metal arranged in the Cassegrain form. Mrs. Huggins and myself on 1894 Jan. 12 compared the image of the Nova with that of the small star 85" *n.f.*, which was only a little less bright, observing with a series of eyepieces magnifying from 100 up to about 700 diameters. The Nova, which of course came to focus absolutely with the star, presented always an appearance precisely similar. We remarked particularly that with the highest power the image was as small and as sharply defined a point as that of the star. On the night of Jan. 12 definition was excellent here; and beyond all doubt, under the conditions above described, the Nova appeared as a true star. WILLIAM HUGGINS.

Upper Tulse Hill, London, S.W.,
1894, Jan. 18.

Selenographical Notes.

STÖFLER, FARADAY, AND FERNELIUS.—It is a remarkable and suggestive circumstance, evident to anyone who examines a good map of the Moon, that the south-west quadrant includes far more examples of interfering and overlapping formations than the other three sections. It is also very clear, when we go more carefully into the matter, that the instances of these departures from the normal type are most numerous on that area of the visible surface extending from the region surrounding the south pole and bounded roughly on the west by the 30th meridian, on the north by the 20th parallel south of the equator, and on the east and south-east by an irregular line passing east of Purbach, Heinsius, Clavius, and Klaproth, to Newton. Nearly all the larger walled-plains in this region belong to this class, of which Maurolychus, Stöfler, Zagut, and Gemma Frisius may be instanced as typical illustrations. We may search in vain north of the equator for objects which exhibit deformation on this extended scale, though in Copernicus, Archimedes, Plato, Aristoteles, and others, we have enclosures approaching, if not exceeding, in area and in other dimensions some of the compound formations so characteristic of the south-west quadrant. It is also noteworthy that these examples of overlapping are mostly confined to the lunar highlands—the great walled-plains and ring-plains on the Maria and other low-lying regions (however complex in other respects) being marked by the absence of this peculiarity. Another fact, perhaps worthy of passing notice, is that these vast deformed rings are for the most part situated on the area where the rays emanating from the Tycho region lie the closest and are the most conspicuous—so conspicuous indeed, that Maginus, Maurolychus, Stöfler, and a host of minor objects are, under a high Sun, rendered practically untraceable through their brilliancy.

Among these irregular formations, the great walled-plain Stöfler, with the associated depressions Faraday, Fernelius, and numberless smaller enclosures, is one of the largest and most interesting, though, in common with its neighbouring compeers, it is apparently neglected by observers, probably because of the hopelessness of attempting to describe or portray a tithe of its details within a reasonable time.

The best general view of the group is obtained when the west long. of the morning terminator varies from 4° to 1°. At the latter phase the interior of Stöfler is about half illuminated and the rims of Faraday and Fernelius are just in sunlight. This affords a far more striking picture of the formation than any obtainable under a setting Sun, as the prominent shadows of the peaks on the eastern walls of the last-named objects appear on the floor of the great walled-plain, and we get also a more satisfactory view of the interior.

On January 6, 1892, at $5^h\ 30^m$, the west long. of the morning terminator being rather more than 3°, an excellent view was afforded with a power of 284 on a 8½-in. Calver reflector under good atmospheric conditions. At this time all the eastern quarter of the interior was free from shadow, the tone of it being a very decided greyish-blue or slate colour. Five craterlets were easily visible on the north-eastern section, and two or three more were glimpsed with some difficulty on the floor north of the large crater E (Neison, Map 17) on the south wall. I noted also (its base abutting on the east wall) a dusky triangular patch, very similar in size and shape to that found in a similar position within Alphonsus. It is situated just below the peak marked δ by Neison. It was again seen, under less favourable conditions, last month. No part of the west border of Stöfler or of the interfering formation Faraday appears to have a very definite raised rim, hence differing greatly in this respect from the opposite side, which has peaks rising to more than 10,000 feet above the interior. The eastern wall is also much terraced and there is a prominent ridge with two bright oval mountains which follows its inner foot from the crater E nearly up to Fernelius.

Neison shows more than twenty minute craters and crater-pits on the floor, Schmidt only nine or ten. In Faraday I have noticed five, and two in Fernelius. Neison and others have seen many more in these formations.

Beaumont House, Shakespeare Road,
Bedford, 1894, Feb. 19.

THOS. GWYN ELGER.

The Total Solar Eclipse of 1896.

WITH a view to making public all information which may be of use to persons arranging expeditions to view this eclipse we propose to publish from time to time such correspondence on the subject as may reach us. The following letters have been supplied by the Eclipse Committee of the R.A.S. :—

From Rev. E. LEDGER *to* Prof. TURNER.

"I will gladly make any enquiries in my power. I am booked to go on s.s. 'Kong Halfdan,' leaving Bergen July 2nd, due Hammerfest July 11th. I only go to N. Cape and back to Molde, not to Vadsö and the Varanger; but my captain will probably know Vadsö well. You doubtless know the Steamship Company's agents at Vadsö are Ientoft & Co. I may see some of the firm at Bodö, where they are also agents. P. 88, Johnson's Eclipses, names Tana, and $5^h\ 53^m\ 53^s$ A.M., Aug. 19, 1896, altitude of Sun 15°, which is, I suppose, all wrong*. I will write to Mr. Downing. He might give me a chart of the shadow to show to a captain or others, and tell me correct altitude. I should chiefly fear fog."

"Barham, 1893, June 13."

From Rev. E. LEDGER *to* Prof. TURNER.

"Besides enquiring from any sources that may be available while I shall be near the N. Cape, I have asked a cousin of mine about Nova Zembla, and enclose you his letter. He was Doctor to Leigh Smith's Expedition on the 'Eira,' which, you may remember, was destroyed in the ice, and the crew, I believe, wintered on Franz Josef Land.

"I hope this information may be of some little use.

"We start, if all be well, 10 A.M. Wednesday."

"Barham Rectory, 1893, June 26."

[*Enclosure.*]

"I do not know anything about Vadsö, but I should say in August you would find plenty of people there, and no difficulty in obtaining any information.

"As to Nova Zembla, we landed in Mutotckkin Straits in August 1882, and as a rule any ship can reach the land in the first week in August. One or two weeks camping would be very enjoyable; no darkness, very warm days, cold at night, but nothing Arctic; in fact the climate is much the same as that of Norway during the summer.

"If I can give you any further information I will gladly do so;

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* We find that Mr. Johnson, in his later book 'Eclipses and Transits in future Years,' corrects the date to Aug. 9, 1896. The other details are approximately correct, but Johnson does not profess great accuracy.

but I am sure any Norwegian will tell you Nova Zembla would be a very enjoyable place for an expedition to spend a few weeks in a tent with good sleeping-bags. Sincerely yours,

"W. H. Neale."

"P.S.—Cannot say it will not be foggy, but in August there is less chance of fog than in June or July; but in any way it would be a very enjoyable time to camp out."

A Remarkable Meteor.

From various parts of the kingdom come reports of a brilliant meteor seen in daylight on Feb. 8, within half an hour after noon. Dr. A. A. Rambaut, Astronomer Royal for Ireland, says:—

"A very remarkable meteor was observed here on Thursday, February 8, in full sunshine, within three minutes of noon. I was looking towards the East, when it suddenly burst into view with an intense brilliance, and shone out against the cloudless blue sky with a greenish metallic lustre.

"It fell in a vertical direction, as nearly as I could judge, and first appeared at an altitude of about twenty-five degrees, and descended rapidly until it disappeared, at a height of about five degrees, behind some trees. The bearing of the object was very approximately ten degrees N. of E. In shape it resembled a very elongated pear, like most fireballs of the sort. It emitted no visible sparks, and disappeared quite noiselessly. The time of the occurrence was twelve hours twenty-eight minutes mean Greenwich time."

It is reported also as having been seen at Dudley, Handsworth, Burton-on-Trent, Kingswood (Warwick), Ely, and Shrewsbury. The observer at Dudley says (we quote from a letter in the 'Standard' newspaper) "his meteor burst within six feet of him," while the observer at Kingswood said "his burst in the next field about two feet from the ground," and another, "the meteor appeared to dissolve in smoke"; with reference to which discordant accounts Dr. Rambaut thinks that it would be interesting to know whether anything in the nature of a fall of stones or iron has been noticed in South Yorkshire or the adjoining counties. He also says:—"The body was first seen at a height of about 87 miles over the Irish Sea, at a point situated in longitude 3° 52′ W., and latitude 52° 36′. It travelled rapidly across Lancashire and disappeared at a height of from 15 to 20 miles, in longitude 1° 36′ W., and latitude 53°, or perhaps a little farther south."

A telegram from America reports that a ship's captain saw a brilliant meteor, in daylight, on his voyage across the Atlantic, but omits the date of the apparition.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Nova of 1572 as observed in England.

GENTLEMEN,—

Although English astronomy can hardly be said to have begun until the following century, one is glad to know that Tycho's star was not only seen but observed in this country; and as there are not many references to this in books, a few words on the subject may be of interest to some of your readers. In his 'Annals of the Reign of Queen Elizabeth, anno 1572,' Camden thus mentions it:—

"I know not whether it be worth while to mention that which all Historiographers of our Time have recorded, *viz.*, That in *November*, a new Star, or, as some style it, a *Phænomenon*, appear'd in *Cassiopea's* Chair; which (as myself observ'd) in Brightness exceeded *Jupiter* in the *Perigee* of his *Excentric* and *Epicycle*. It continu'd in the same place, full Sixteen Months, being carry'd about with the diurnal Motion of the Heaven. *Thomas Digsey* and *John Dey*, two famous Mathematicians amongst us, have learnedly prov'd, by the Doctrine of *Parallaxes*, that it was in the Celestial, not in the Elementary Region; and were of opinion, that it disappear'd by little and little, by ascending. 'Tis certain, that after Eight Months, all Men perceiv'd it to grow less and less. *Theodore Beza* wittily apply'd it to the Star, which appear'd at the Birth of Christ, and the Slaughter of the Infants under *Herod*; and admonish'd *Charles* IX, King of *France*, who had acknowledg'd himself Author of the Massacre of *Paris*, to beware, in this Verse,

"Tu vero, Herodes, sanguinolente, time,

i. e.

"And look thou, bloody Herod, to thyself.

"Nor was he out in his Conjecture; For, in the fifth Month after the disappearing of this Star, after long and horrible Pains, he died of excessive Bleeding."

So far Camden. The names of the "famous Mathematicians amongst us," to whom he refers, are usually spelt Thomas Digges and John Dee. Of the latter, who prostituted his undoubted talents to the black art (literally black, for his magic mirror appears probably to have been a piece of polished coal), I need say no more. But Digges's observations of the Nova of 1572 are quoted by Tycho Brahe and compared with his own. They are to be found in a small tractate, "Alæ seu Scalæ Mathematicæ," published in 1573, which gives the distances "Phænomeni cœlestis insoliti" from the six principal stars in Cassiopeia, and describes the writer's astonishment, when he first noticed the stranger, at perceiving that it was "sine Crine, Coma, aut Cauda," and his afterwards finding, as the result of repeated observations, that it must be situated at a far greater distance than the Moon.

In this little treatise and in the preface thereto (which is longer than the work itself) Digges speaks of Copernicus in a way which shows that the heliocentric theory of the planetary system commended itself to him as in all probability the true one. But this appears still more clearly in an unpaged supplement which he published in 1578 to a new edition of his father's "Prognostication Everlasting." The title of this addition (which might have been better known had it been published separately) is "A perfit description of the Cœlestiall Orbes, according to the most ancient doctrine of the Pythagoreans, lately revived by Copernicus, and by Geometricall Demonstrations approved." It is refreshing to find, thirty-five years after the death of Copernicus, so strenuous an adherent of his views in this country. And I would venture to commend also the author's remark that Aristotle did not hold the contrary view so dogmatically as has been generally supposed. Digges, who may well be regarded as the morning star of English astronomy, died in 1595. He was a native of Wootton, near Barham, in Kent, between Canterbury and Dover.

Yours faithfully,

Blackheath, 1894, Jan. 30. W. T. Lynn.

Supposed Dispersion of Cloud under the Full Moon.

Gentlemen,—

I was much interested in seeing that a paper by the Rev. S. J. Johnson had been read at the January meeting of the Royal Astronomical Society upon the question of the supposed disappearance of cloud under a full Moon, in which, from observations made during the fifteen years 1879 to 1893, he shows that there is no perceptible effect. I may, perhaps, be permitted to point out that I discussed the same question many years ago, the complete details of the investigation being contained in a paper contributed to the 'Philosophical Magazine' for July 1867, in which, employing the two-hourly observations of the estimated amount of cloud made at the Royal Observatory, Greenwich, during the years 1841 to 1847, I arrived at a precisely similar result.

I was induced to make the inquiry in consequence of my many years' experience as an astronomical observer having led me to doubt the fact that any influence of the kind, perceptible to common observation, existed, although such had been affirmed by Humboldt, Herschel, and Arago. I had remarked also that Admiral Fitzroy had stated that in fine weather there is a general tendency towards a disappearance of clouds soon after evening, "whether the Moon is visible or not, whether full, or near any other period."

In the same paper I suggested an explanation of the causes that, in my opinion, lead to the impression that the full Moon disperses cloud, which it may be interesting here to reproduce. Premising that the ordinary diurnal change in the amount of cloud, as found from the observations of *all* days in the 1841–1847 series, is from a more cloudy state by day to a less cloudy state in evening, with a tendency again to more cloud as the night advances, it will be remarked that the period of evening clearance corresponds at the time of full Moon, and at that part of the lunation only, to about the period comprised between the rise and advance of the Moon towards the meridian. There is thus, near the time of full Moon, an appearance of *cause* and *effect*. But the transition from a cloudy to a clear state of sky is much more likely to attract attention when there is a full Moon than at other times, for with no Moon present the general darkness becomes little altered, whilst under a full Moon dissipation of cloud in evening so entirely changes the aspect of things that the contrast between the previous dulness and the brilliant moonlight is very striking. So that the Moon may, by her presence, first attract attention to the evening clearance, and then, by accident of position —the coincidence near full Moon of her time of rising with this clearance—suggest the idea that to her influence the effect remarked is due, one that on a moonless night might by many scarcely be observed. Whether or not this be a true explanation of the way in which the impression of lunar influence arises, we see that the result arrived at by the Rev. S. J. Johnson entirely corroborates that which I had also found, both negativing the supposition of any definite lunar effect. Yours faithfully,

Greenwich, 1894, Feb. 17. WILLIAM ELLIS.

The Comet or Comets of A.D. 1402.

GENTLEMEN,—

Herr Helmolt has lately published in the 'Astronomische Nachrichten' a list of all the historical references he could find of the comet observed in Western Europe in the spring of 1402. It is a very remarkable thing that two comets are recorded as having been seen in that year, both of which were bright enough to be visible in broad daylight. Carl ('Repertorium der Cometen-Astronomie,' p. 42) remarks that the different accounts are both obscure and contradictory, and give occasion to a conjecture that they all really refer to one and the same (very large) comet. Dr. Hind, however, kindly informs me that he still continues of Pingré's opinion that there were two, though he found the accounts so confusing that it was impossible to determine an orbit from them with any probability. May we hope that an examination of Herr Helmolt's list will lead to a discrimination between the accounts and to a probable idea of the path of at any rate one of the two comets, if there were really two. It is much to be regretted that the Chinese records fail us here and (as Dr. Hind was informed by Mr. Williams) contain no account whatever of a comet seen in that year. They also, by the way, fail to mention the Tycho star of 1572, though the appearance of that of 1604 is recorded. Yours faithfully,

Blackheath, 1894, Jan. 11. W. T. LYNN.

Solar Outbursts and Terrestrial Magnetism.

Gentlemen,—

In the Notes of the January number of the 'Observatory,' p. 65, you give Mr. Ellis the credit of first protesting against the widely taught belief that the luminous solar outburst observed by Messrs. Carrington and Hodgson in 1859 was accompanied by a disturbance of terrestrial magnetism. Might I point out that the protest was made in 'Nature' of November 2, 1893 (p. 2), and that Mr. Ellis then took up the matter and clinched it with the weight of his authority? Yours truly,

1894, Feb. 18. R. A. Gregory.

The Drawing of Jupiter's Third Satellite in Transit by the late Mr. Dawes.

Gentlemen,—

Unfortunately I came late to the R.A.S. meeting on January 12 last; but on receiving the 'Monthly Notices' last night, containing the beautiful drawing of Jupiter's first satellite by Mr. Barnard, I at once remembered Mr. Dawes's drawing of the third satellite, in transit, in the 'Monthly Notices,' vol. xx. p. 245. Mr. Dawes gives drawings of this satellite as shown with his 6⅓-inch refractor, and also with his 8¼-inch refractor by Alvan Clarke. Had he on the latter occasion (1860, January 31) had 36 inches aperture at his command, I cannot help thinking he would have made a drawing very similar to Mr. Barnard's, showing dark polar regions separated by a lighter equatorial belt.

Yours faithfully,

West Dulwich, 1894, Feb. 14. George Hunt.

OBSERVATORIES.

Stonyhurst College Observatory.—In the small pamphlet setting forth the work done during the year 1893 under the direction of Father Sidgreaves we have an immense amount of information respecting the meteorological and magnetic conditions of the neighbourhood, as well as detailed accounts of the solar surface for each observing day. Some remarks from the introduction we give here:—

"The long drought which affected the farming interest over the greater part of Europe, and the southern and midland counties of England, was only partially felt at Stonyhurst; and it is remarkable that the total rainfall of the 12 months is in excess of the average by over three inches."

"The new objective, with its mountings, arrived at the beginning of November, and was erected on the 6th. It has a clear aperture of 14⅞ inches, and was worked by Sir Howard Grubb. It cost £600, and constitutes the substantial tribute to the memory of the late Father Perry, raised by the generosity of his many friends."

There is the customary appendix, containing the results of the meteorological observations taken at St. Ignatius' College, Malta.

PUBLICATIONS.

TOBIAS MAYER'S STERNVERZEICHNISS *.—" It is needless for me to enter into any panegyric on the celebrated catalogue of stars, deduced from the observations of TOBIAS MAYER, and which consequently bears his name. The zeal and ability of the observer, and the excellence of the instrument employed by him, at a period when good instruments were not so attainable as at the present day, have stamped on it a reputation which will last as long as the science of astronomy exists. The work itself has always been scarce in this country, and I believe is known here chiefly through the imperfect version of it in VINCE'S ' System of Astronomy.' "

Such is the opening paragraph of the memoir † in which Baily rediscusses the original observations, which had been printed by the Commissioners of Longitude in 1826, and deduces from them a fresh catalogue, epoch 1756, and a new comparison with Bradley's observations. Bessel had already compared the catalogues of Mayer and Bradley in his 'Fundamenta.' Baily found out several errors, and added several stars previously overlooked; but did nothing towards that discussion of systematic corrections which characterizes modern astronomy, and of which Dr. Auwers has shown himself to be such a master. The differences between Mayer and Bradley often exceed 10″ in both elements; and there is a systematic difference of 4″·3 in the declinations which Baily does not attempt to correct, though it is now simply called an index error.

In the course of his work on Bradley's observations Dr. Auwers was struck with the fact that Mayer's observations would probably also be well worth rediscussion. He commenced the work in 1877, but could not personally superintend it continuously, owing to the pressure of other work. It has been completed with the assistance, gratefully recognized in the preface, of the late Herr Sievers and Dr. Lamp, and of Prof. Müller, Dr. Battermann, and others. The result is a Catalogue of 1027 stars for the epoch 1755, fulfilling all modern requirements, and of the greatest value for the discussion of proper motions.

" MAYER was only thirty-nine when he died in 1762. He was appointed director of the observatory at Göttingen, founded by his late Majesty George the Third, in 1756; and he continued to make observations there till the time of his death; but the major part

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* Tobias Mayer's 'Sternverzeichniss nach den Beobachtungen auf der Göttinger Sternwarte in den Jahren 1756 bis 1760 neu Bearbeitet von Arthur Auwers.' W. Engelmann: Leipzig, 1894. Price 22 Marks.

† Mem. R.A.S. iv. p. 391.

of those observations were made in the years 1756 and 1757, during part of which time the City was besieged by an invading army, and whilst it was unsafe to venture into the observatory, which was very much exposed to the fire of the enemy . . . .

"The instrument with which Mayer made his observations was a brass quadrant of six feet radius, made by Bird; divided on the limb in three different ways . . . .

"Mayer had no transit-instrument for determining the right ascensions of the stars; but took them with the telescope of his quadrant, which was furnished with five vertical wires." *

Dr. Auwers has carefully discussed the instrumental errors of this quadrant, and the rate of the clock, which was not compensated, and thus had a considerable daily rate. We can best illustrate the results of his labour by examples. Mayer's right ascensions were formerly considered inferior in value to his declinations. Here are the fractions of a second for the R.A. of a star picked quite at random, as shown in Auwers' new ledgers; it happens to be ψ Leonis, the h. m. s. being $9^h\ 30^m\ 21^s$+ :—·65, ·79, ·65, ·70, ·72, ·53, ·55, ·74, ·77, ·85, ·80. When we learn that "Mayer seldom observed a star at more than one wire, unless it were one of considerable magnitude," our admiration for this series, which might almost have been an extract from a modern catalogue and is by no means exceptional, is so great that it may well be shared between the man who made such observations and the man who has after more than a century pointed out their true value.

Again, let us take the old and new differences between Bradley and Mayer. Here are a few examples taken quite at random :—

	Bradley—Mayer.			
	Baily.		Auwers.	
Star's Number (Baily).	R.A.	Dec.	R.A.	Dec.
565	−13″·8	− 4″·3	−0s·07	+1″·5
566	+ 6 ·0	+ 1 ·2	−0 ·55	+1 ·2
567	− 5 ·8	− 5 ·5	+0 ·14	−0 ·8
891	− 5 ·8	− 6 ·5	−0 ·12	+0 ·9
892	+10 ·7	−12 ·1	−0 ·14	−4 ·8
893	− 8 ·9	− 7 ·1	−0 ·03	+0 ·9
200	−11 ·0	− 1 ·2	0 ·00	−0 ·8
201	+ 6 ·9	+ 0 ·3	−0 ·24	+0 ·6
202	+ 2 ·1	− 3 ·4	+0 ·05	−1 ·1

Such numbers speak for themselves. It only remains to add that a complete discussion of proper motions, both of Bradley stars and others which are now carried back to Bradley's epoch, is included in the volume, which we may now look upon as a classic.

Annals of the Astronomical Observatory of Harvard College, Vol. XXV.—This volume contains the proper motions

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* Mem. R.A.S. iv. pp. 391, 392.

deduced by Prof. Rogers from his observations of stars between 50° and 55° North Declination, made during the years 1870–78, and 1883–86, in connection with the Catalogue of the Astronomische Gesellschaft. The ledgers of the individual results, reduced to the epoch 1875·0, are given for each star at the end of the volume; and the mean results for the same date are compared with similar results, deduced from some 32 catalogues, for all stars in this zone which have been observed during the years 1790–1880. Systematic corrections, deduced by a graphical process, have been applied to each catalogue, to reduce the declinations to the system of the Astronomische Gesellschaft. No amount of pains seems to have been spared in determining the values of these assumed deviations from the system of the zone catalogue, which are tabulated for every half-hour of Right Ascension. For the Greenwich catalogues the average number of points on the curve of correction for each catalogue was 30, with an average number of not quite 2½ stars for each point. Considering that many of these star-places depend on two observations only, the data upon which the corrections are based appear scarcely sufficient to justify the amount of labour that was necessarily expended in obtaining them. The proper motions are then obtained by comparing the Harvard College observations with those of each catalogue, corrected to the Astronomische Gesellschaft system, adopting for the final results the mean of all the different determinations. Prof. Rogers is fully alive to the objections to such a method of determination, as virtually depending on the places of a single catalogue. The amount of work thus involved is very considerable, and it would have been as easy and more accurate to plot down the reduced places, and simply draw the best possible straight line through all the results, where the difference of ordinates would represent the amount of proper motion corresponding to the interval of time given by the corresponding abscissa. Except for the Harvard College observations the epoch of each catalogue has been assumed to be the mean epoch of the observations, an assumption that is hardly consistent with elaborate systematic corrections. The values of the R.A. and declination, given as α_0 and α, and δ_0 and δ, do not seem to agree with the description given under the explanation of the printed pages. Such systematic corrections as are here given to so many catalogues are made on the assumption that the proper motion of each star carries it forward on a great circle with a uniform velocity; the question is, does it? W. G. T.

ANNALES DE L'OBSERVATOIRE DE PARIS.—The latest Paris volume, containing the observations for 1885, published under the direction of M. F. Tisserand, has just reached us. It contains the usual routine observations and reductions, and a few meteorological observations. In all there is a large amount of work. There is also an Appendix, entitled "Instructions sur l'usage de l'équatorial et sur la réduction des observations," by M. Bigourdan. This is a very useful, practical, and complete exposition of the method of making and reducing extra-meridian observations. The thoroughness with which M. Bigourdan has done his work is evidenced by the long and complete tables for facilitating the reductions, and his notes on star catalogues. Both these chapters ought to prove of great value.

NOTES.

Comet Notes.—In a thesis presented to the Faculty of Sciences in Paris for the degree of D.Sc., M. Fabry, of the Marseilles Observatory, examines the question whether comets have their origin in the solar system or come from outside space. On the hypothesis that they come from outside, he finds that on the assumption of the Sun's immobility hyperbolic orbits would be frequent; while on the assumption that the Sun is moving with a speed of one quarter of that of the Earth in its orbit, practically all the orbits should be hyperbolic, and strongly marked hyperbolic orbits should be quite frequent. As, in fact, strongly marked hyperbolæ never occur, while hyperbolæ as a whole are decidedly rare, he concludes that comets are to be regarded as members of our own system. From an examination of the elements of all known comets he finds no indication of the solar motion, which again supports the above conclusion, as if the original velocity of comets were quite independent of that of the solar system the latter would produce strongly marked characteristics in these elements regarded as a whole.

In the 'Astronomical Journal,' No. 310, there is an investigation by Prof. J. G. Porter of the orbit of Comet 1892 (Barnard). Only 31 observations are available, extending from 1892 Oct. 13 to Nov. 21, and the conditions are not favourable for a very exact determination. The following are the resulting elements, for comparison with which are given the elements of Wolf's Comet (from Ast. Nach. 3050). It will be remembered that the resemblance between these elements was pointed out by Herr Schulhof shortly after the discovery of the comet.

	Barnard's Comet.		Wolf's Comet.	
Osculating epoch.	1892 Oct. 22·5 Berlin M.T.		1891 July 10.	
M_0	352° 8′ 14″·48		Perihel. Pass. 1891 Sept. 3^d 11^h 21^m Paris M.T.	
π	17 1 34 ·20	1892·0.	19° 11′ 38″	1891·0.
☊......	206 42 28 ·60		206 22 29	
i	31 10 35 ·60		25 14 33	
ϕ	35 19 12 ·37		33 51 29	
$\log \mu$ ..	2·7558134		2·7161472	
$\log a$ ..	0·5294621		0·5559063	
Period ..	6^y·226		6^y·821	

Prof. Porter concludes from the situation of the orbit that there is little prospect of seeing the comet till its fourth return in 1917.

In Ast. Nach. 3207 there is a definitive investigation by M. Bobrinskoy of the orbit of Denning's Comet (1890 VI.). The perturbations by Jupiter and the Earth, though very minute, are taken into account. The following is the final orbit:—

$$T = 1890 \text{ Sept. } 24{\cdot}545245 \text{ Berlin M.T.}$$

$$\left.\begin{array}{ll} \pi \ldots\ldots & 163^{\circ}\ 2'\ 17''{\cdot}84 \\ \Omega \ldots\ldots & 100\ \ 7\ 12\ {\cdot}81 \\ i \ldots\ldots & 98\ 56\ 30\ {\cdot}39 \end{array}\right\} 1890{\cdot}0.$$

$$\begin{array}{ll} \log q \ldots & 0{\cdot}100448 \\ e \ldots\ldots & 0{\cdot}9991542 \end{array}$$

Brooks' Comet *c* 1893 was followed with the 16-inch at Carleton College Observatory, Minnesota, till Jan. 26, but it was then so faint that no measures could be made. Holmes' Comet was searched for visually and photographically at the same place, but without success; a stain on the plate, however, covered the place where the comet was expected to be. A. C. D. C.

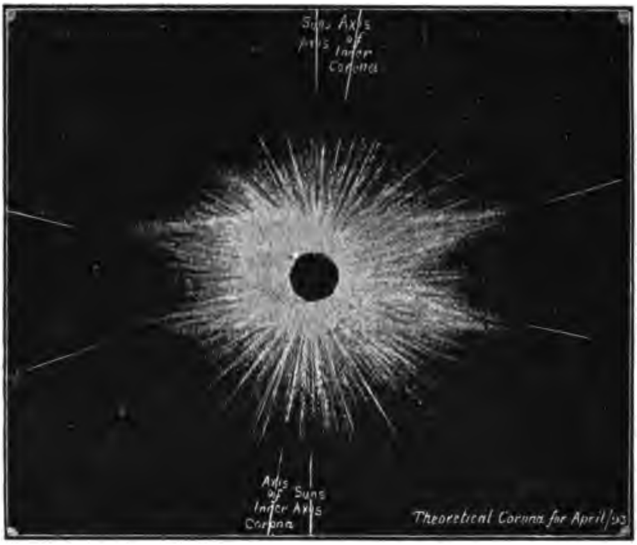
MINOR PLANET NOTES.—The following have been discovered since the note in the last number:—

AT	Jan. 29.	Charlois, Nice.
AU	„	„
AV	Feb. 16.	Courty, Bordeaux.
AW....	18.	Wilson, Northfield.

The latter discovery is interesting from the fact that the planet had passed opposition some four months; it will probably be fairly conspicuous when in opposition.

The following six planets, all discovered by M. Charlois in 1893, have received permanent numbers:—AJ=(373), AK=(374), AL=(375), AM=(376), AN=(377), AP=(378). AO does not receive a permanent number, not having been sufficiently observed.

WE give as Frontispieces to this Number pictures of the corona as seen and photographed during the Total Solar Eclipse of April 16 last, by the expedition sent from the Lick Observatory. These are copied from a glass negative kindly supplied by Prof. Holden. The other pictures of the corona as seen during the eclipses of December 1871 at Baikul, India, and May 1882 at Sohag, Egypt, are copied from the drawings made by Mr. Wesley from the photographs taken on these occasions. In these two last the projection of the Sun's axis is represented by a vertical line through the centres of the plates: in 1871 the north point of the Sun's disk is about 12° to the west of the projected north pole; in 1882 it is about 21° toward the east. We have brought the pictures of these three eclipses together, as the sun-spot period was at about the same phase at the three epochs, and the similarity or dissimilarity of the coronal appearance at similar phases of the cycle can thus be easily judged. The approach to a gap in the equatorial region in both 1882 and 1893 is to be remarked, whereas the opening at the poles, so conspicuous in 1871 is not at all seen in 1893.



The above is a copy of the picture of the appearance of the corona as predicted by Prof. Schaeberle for April 1893, according to his mechanical theory, and published by him in 'Astronomy and Astro-Physics' of January 1893, for comparison with the actual corona as seen. In a private letter to us Prof. Schaeberle expresses his opinion very strongly that the appearance of the corona in 1893 is in accord with his prediction.

ANENT a criticism of Prof. Schaeberle's theory of comets which appeared in our number of December last, and in which we questioned whether his reasons would not be equally good reasons for arguing that Mercury and Venus should have tails, Prof. Schaeberle says:—"It is evident the planets, on account of their great mass, will not allow nearly grazing particles, originally ejected from the Sun, to form a tail, for all such particles will be deflected from a radius vector; as seen from the planet the density will evidently be greatest 180° from the Sun, where the new orbits described cross each other. It is also evident that on account of the comparatively small depth of the atmosphere of a planet, nearly all the coronal particles actually striking such an atmosphere will be permanently captured."

We have reason to know that Sir Henry Thompson, the eminent surgeon, has offered the magnificent sum of 5000 pounds sterling to the nation, through the Astronomer Royal, for the purpose of buying a telescope for Greenwich Observatory. It is not often Astronomy finds such a generous patron, on this side of the Atlantic at least, and, moreover, one who can so well appreciate the exact needs of the science at the moment. For Sir H. Thompson foreseeing that the Astronomy of the future is to be photographic, and feeling that England should be well-equipped in this arm, makes it a condition of his gift that the telescope is to be expressly designed for photographic purposes. So far as the plans are made, and subject to the acceptance of the offer by the Government, the instrument is to be of 26 inches aperture, just twice that of the telescopes used for the Photographic Chart of the Heavens—in fact the instrument (which will probably be made by Sir H. Grubb) is to be made from the model of the Astrographic Equatorial, but of exactly double the dimensions in every particular. The guiding telescope for the new instrument will be the 12¾-inch Merz refractor with a light tube; and the 9-inch photographic objective presented by Sir H. Thompson to the Royal Observatory some three years ago will also be carried on the same mounting for use as a photoheliograph as at present.

The new instrument, when completed, will be housed under the Lassell Dome, on the top of the central octagon of the new Physical Observatory, now being built in the south grounds of the Royal Observatory.

LARGE SUN-SPOT.—There is at the moment of writing, Feb. 27, a spot on the Sun visible to the naked eye. Its area on Feb. 20 (it was first seen at Greenwich on Feb. 18) was measured as 1900 millionths of the solar hemisphere, which, though large, is little more than half the area of the great group of February 1892. We are permitted to publish the following report of a simultaneous disturbance of the Greenwich magnetometers:—

"A considerable magnetic disturbance was observed to begin very sharply at $8^h\ 15^m$ P.M. on Feb. 20, and the movements continued to be pretty active till $11^h\ 0^m$ P.M. on Feb. 21. The magnets then remained fairly quiescent for 24 hours, when the disturbance recommenced with greater intensity than before, continuing until 2^h A.M. on the 26th, with another quiescent period between 7^h A.M. on Feb. 24 and 7^h A.M. on Feb. 25. It was specially active in all the elements about 3 o'clock in the morning of Feb. 23, during the night of Feb. 23–24, and throughout the afternoon and evening of Feb. 25. The disturbance, though a very noticeable one, is of quite a secondary order as compared with those which were synchronous with the great sun-spots of April and November 1882, or with the still greater sun-spot of February 1892."

In 'Astronomy and Astro-Physics' for January, Dr. J. M. Thome, the present Director, gives an account of the work done at the Cordoba Observatory since its creation in 1869; his article ends with the following paragraph:—

"I think most astronomers, especially those of maturer age and experience, will agree that our time and means have been well and diligently employed, whatever lack of brilliancy there may be in the achievement. What we have accomplished was done by concentrating our energies and directing them upon one distinctive object. There has never been more than one director at a time in our Institution and the principle seems to have worked well."

We fancy the last sentence has obscure reference to another American Institution, but the tale of the work done at the National Argentine Observatory by Drs. Gould and Thome is evidence of the wisdom of the policy above laid down.

Prof. E. C. Pickering has examined the Harvard College photographs containing the star in Andromeda (R.A. $0^h\ 14^m\ 48^s$, Dec. $+26^\circ\ 10'\cdot 3$, 1855·0) discovered to be variable by the Rev. T. D. Anderson in November last, for the purpose of discussing the variability of that star. He discovers that its period is 281 days, and that a maximum occurred on the Julian day 2398587. The next maximum will therefore occur on March 30, 1894. The magnitude will then be 9·0, and from the photographs referred to above it appears that for three months preceding the maximum the increase of brightness was perfectly uniform and at the rate of one magnitude in 26 days; after maximum the decrease was still uniform and at the rate of one magnitude in 25 days. From a table given by Prof. Pickering (A. N. 3213) the magnitudes as observed on the photographs are perfectly in accordance with the above laws.

We need scarcely inform our readers that the eyes of England, if not of the world, have been centred on the neighbourhood of Greenwich during the last week or two. Notoriety from such a cause is hardly worth the risk run in obtaining it. The explosion of an Anarchist bomb so near our National Observatory, whether as the result of evil design or otherwise, is a little unsettling.

It may be worth while to put on record here the facts as known to those inside the Observatory. On the afternoon of Feb. 15, soon after the close of the usual office-hours, when few persons were on the premises, an explosion, rather louder and more protracted than a rifle-shot, was heard ($4^h\ 51^m\ 25^s$ G.M.T.), apparently quite close to the Observatory. Looking from the boundary-railings a little later, Messrs. Thackeray and Hollis, and MacManus the gate-porter, saw a man picked up by the park-constable in the "zigzag," a path in a secluded part of the Observatory Hill. Going to the spot they found the man terribly mutilated, and with his left hand completely severed from his wrist. The man died shortly afterwards. The subsequent investigation, which was carried out in the fullest manner by Government officials, leaves no room for doubt but that the man was one of a band of foreign Anarchists now living in London, and that he had brought an explosive bomb to Greenwich for the purpose of damaging the Observatory and its contents, which exploded as he was in the act of preparing it for its final purpose. But it is not evident why he should have thought that the destruction of scientific instruments could in any way help any quasi-political cause. His intended programme might be described as one of safety, simplicity, and sensation; and it is gratifying to find that the first item of this policy was not practicable.

THE only amusing thing in connection with the incident was a letter from a person who wished the Astronomer Royal to use his influence to put a stop to Prof. Dewar's experiments, which he (the correspondent) thought were encouraging Anarchical methods.

A CONGRATULATORY dinner was given to Prof. Turner in celebration of his election to the Savilian Chair, at the First Avenue Hotel, on Wednesday, Feb. 14th, by the Members of the Observatory Staff and several astronomical friends. There were present, besides the Observatory Staff, Messrs. W. Airy, F. W. Dyson, Dr. A. A. Common, Messrs. E. Dunkin, W. Ellis, W. C. Johnson, G. Knott, W. H. Maw, G. C. Pulsford, Dr. Spitta, Messrs. S. Waters and W. H. Wesley. Letters and telegrams of congratulation and of regret for inability to attend were read from Capt. Abney, Mr. F. McClean, Mr. W. E. Plummer, Prof. McLeod of Montreal, and Messrs. Dickenson and Wilmot, of the Commercial Cable Company.

MR. RIDER HAGGARD may be a very excellent novelist but he is hardly an astronomer. A novel of his is now being published in a journal which enjoys a large circulation; and a correspondent writing to that journal points out some remarkable lunar vagaries said to happen therein. To wit: the Moon is said to *rise* in the evening, which we take it implies that the Moon must be full or about the full; then, according to the novelist, the Moon is visible for the next seven nights, but during the eighth night *it sets*, and on the next night, about the ninth after full Moon, it rises *full*. Truly a wonderful lunation—almost as wonderful as Mr. Haggard's other instance in one of his earlier novels, where the Moon eclipsed the Sun during the morning, and was full on the evening of the same day!

Such mistakes are not uncommon in pictures, where the crescent Moon at sunset is sometimes drawn with the *following* limb bright. We propose to make a sort of pillory on this page of such mistakes occurring in novels, and shall be glad to receive any instances noticed by our readers. Passing over Dickens's well-known case of a star being in the zenith for several hours, we begin with a lady novelist, who in the description of a sunset states that Venus was *rising* in the eastern sky.

Mr. Ledger seems to have incurred adverse criticism in some quarters by considering the Moon, in a recent Gresham Lecture, as a solar planet instead of a satellite of the Earth. This is merely a matter of terminology. There seems to be no very good reason, except that of quantity, why the Moon should not be considered as moving, as the planets, under the influence of the attraction of the Sun, and perturbed by its nearest neighbour the Earth.

Public interest in Astronomy and Observatories is certainly on the increase. We understand that a play is in preparation for a well-known London theatre in which one scene is to be laid in an observatory. The stage manager and scenic artist have paid a visit to Greenwich in order to get the necessary local colour.

A telegram through the Kiel Centralstelle informs us that the star in Norma, discovered to be variable by Mrs. Fleming in October last, has been observed spectroscopically by Mr. Campbell at the Lick Observatory. The message says:—"Magnitude 9·5, spectrum four bright lines, similar to Nova Aurigæ in August 1892, hence nebulous."

Mr. F. W. Dyson, M.A., Fellow of Trinity College, Cambridge, has been appointed Chief Assistant at the Royal Observatory, Greenwich, in succession to Prof. Turner. Mr. Dyson was Sheepshanks Exhibitioner at Cambridge, and has held the Isaac Newton Studentship for the last two years.

Prof. Turner gave his inaugural lecture in the Sheldonian Theatre at Oxford on Friday, Feb. 23, before a large and distinguished audience. The subject chosen by the lecturer was "The International Photographic Chart of the Heavens."

We have received copies of new editions of Mr. W. T. Lynn's little books 'Celestial Motions' and 'Remarkable Comets.' We can heartily commend this latter as a useful addition to a miniature reference library.

We call attention to an occultation of Spica which will happen on the morning of March 23 (Good Friday), visible at Greenwich; and also to the "near approach" for Greenwich of β Virginis (mag. $3\frac{1}{2}$), which will take place on the morning of March 21.

The Rev. T. D. Anderson reports the variability of a star in Cassiopeia, R.A. $23^h\ 7^m\ 7^s$, N.P.D. $30^\circ\ 53'{\cdot}5$, the magnitude of which is given in the Bonn Durchmusterung as 9·5.

In our last number Mr. W. F. Denning's name was inadvertently inserted at the end of an article on p. 78. He asks us to make this announcement.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 213. APRIL. 1894.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, March 9, 1894.

Capt. W. de W. Abney, C.B., F.R.S., *President*, in the Chair.

Secretaries: Prof. H. H. Turner, M.A., B.Sc., and
E. W. Maunder.

The President. I wish to call attention to the fact that invitations are issued to ladies by the President with the sanction of the Council at the commencement of the Session. I mention this so that there may be no misunderstanding with regard to this Session.

Capt. Noble. I think, Sir, I am not singular in wishing that ladies could claim to sit here as a matter of right.

Mr. Maunder. 103 presents have been received since the date of the last ordinary Meeting of the Society. There are not many calling for special notice; but three volumes of the 'Annals' of the Harvard College Observatory have been issued, one of which, Vol. 25, contains a discussion of the star places of the catalogue made by Harvard in connection with the catalogue of the Astronomische Gesellschaft. Vol. 29 contains a number of miscellaneous researches. Vol. 31 is devoted mostly to meteorological observations. There is also a very important volume by Prof. Auwers, 'The reduction of Tobias Mayer's observations made at Göttingen in the years 1756–1760,' and one by Prof. Gylden, "Analytical Treatise on absolute Orbits of the Planets,' Vol. 1; and there are a number of photographs of portions of the Moon taken at the Lick Observatory and enlarged by Prof. L. Weinek.

The President. Mr. Lewis has prepared a paper on the results of micrometric measures of double stars made in the year 1893. It consists principally of tabular matter, but I should like Mr. Lewis to say a few words about it.

Mr. Lewis. There is very little to say about this paper. It contains results of some micrometric measures made with the

12⅜-inch Merz telescope, mounted on the Lassell equatorial, in the first part of last year, with a power of 412. Besides the measures made by myself there are one or two others made by Mr. Turner.

Dr. Downing. What class of stars did you devote your attention to?

Mr. Lewis. They are mostly stars that are known to be in motion, the distances between the stars ranging from about four-tenths of a second, which is an estimate, to six or seven seconds.

Dr. Downing. What distance can you measure accurately?

Mr. Lewis. About five or six-tenths of a second easily.

Prof. Turner. Mr. Lewis has kindly referred to me in these measures, which gives me an opening to make a protest against the very modest way in which he has brought forward this paper, which is the result of a very large amount of labour and which I am very glad to welcome among the papers of our Society as being so germane to the work of our Medallist of the present year. Mr. Lewis is an enthusiastic admirer of Mr. Burnham, and I am glad to be able to give some testimony to the value of the work he has done in measuring double stars. We have here 2 or 3 pages of work summed up in the clearest manner, and to the value of it I can testify with the greatest enthusiasm. I am sorry Mr. Lewis did not say more on the subject of his valuable paper.

Prof. Turner then read a paper by *Mr. H. C. Russell* on "A Seconds Contact-maker for Astronomical Clocks." The device consisted of a wheel loosely pivoted on the pendulum-rod, which was in contact throughout the swing with a horizontal spring. At the lowest position of the bob of the wheel the spring is sufficiently depressed for its end to make contact with a fixed terminal below it. The paper stated that as the wheel was loose on the pendulum the only resistance was a rolling friction, which had little effect on the going of the clock.

Mr. Cushing. That is an old device.

Mr. Knobel. It seems to me that we should ascertain whether it is an old device, and before we proceed further with the publication of the paper this should be substantiated. If Mr. Cushing can favour us with any further substantiation of that we should like to hear it.

Mr. H. Dennis Taylor. I should like to say that this device was invented and used in some clocks made by Messrs. Cooke & Sons 20 years ago, and it may be seen in an old clock on their premises to-day.

Prof. Turner. In case I may have inadequately explained the paper, will Mr. Taylor look at it and also at the drawings? It is possible I may not have properly explained the matter.

The President. Whether it be old or new, I am sure Mr. Russell would not send anything forward unless it was his own idea, and therefore I ask you to give a vote of thanks to him for his communication.

Prof. Turner next read a paper by *Mr. W. F. Denning* on the brilliant detonating fireball of January 25th, 1894. Mr. Denning, as was his custom, had discussed the subject very completely. About 10 o'clock on the night in question, a large fireball went across the sky from N.W. to S.E., scattering behind it a bright trail of sparks. Mr. Denning had collected 45 descriptions of the fireball, and though the majority of them were of a popular character, he had been able to deduce from the most accurate of them the true path of the meteor and to find its path, which he had tabulated in the form of a diagram.

Mr. Ranyard. I think Mr. Denning in his paper generalizes rather too much. Col. Tupman showed that we have a large number of fireballs or large meteors in November, which nearly follow the Earth in its orbit and would therefore appear at night to come from the westward; but certainly they appear many times in the year, and they cannot all be from the same source. I should have thought they occasionally arrive from all parts of space.

Prof. Turner. I have read only short extracts from Mr. Denning's paper. He says that in the summer and autumnal months there are several routes, &c. It is an exhaustive paper, which I did not venture to read in full.

The President then asked the Astronomer Royal to exhibit the experimental photographs taken with the 28-inch object-glass at Greenwich.

The Astronomer Royal. I propose to show one or two experimental photographs which have been taken with the 28-inch object-glass arranged for photography, that is to say, with the crown lens reversed. But these results must not be looked upon as final. They are exhibited merely by way of showing the difference in images caused by difference in adjustment and the steps by which we have advanced, and I hope we have got fairly near to the proper adjustment of the object-glass. I do not therefore wish to put these forward in any way as definitive. This object-glass has been so arranged that it is in the first place adjusted to give the most perfect visual image; and then, according to a plan proposed by Sir George Stokes, the crown lens is reversed and the lenses are separated. The separation of the lenses introduces some spherical aberration, which should be corrected by the reversal, and the problem is to find the proper distance between the lenses for photographic correction and then to adjust the crown lens exactly to centre with the flint lens. I think we have got very nearly the proper separation of lenses, and we want a slight alteration in the centring, which is a small matter, and only requires a little mechanical work. [The Astronomer Royal then showed on the screen photographs of stars taken with different separations of the lenses, and with different positions of the plate with respect to the focus.] These photographs were taken in the face of many difficulties, due both to the weather (much wind and cloud having been prevalent lately) and to the mechanical conditions, as a new adjustment often requires an alteration of the camera, and the work necessarily proceeds slowly; but I think these photographs show that we have nearly arrived at the best position for the lenses. I feel that I ought to apologize for having brought these rather crude pictures before the Society; but I think it is better to show the steps by which one has led up to a result and the failures rather than to show a final result without the steps by which it has been obtained.

In reponse to a call from the President,

Sir Howard Grubb. It is purely a matter of accident that I am here to-night; I did not anticipate being present, and I was quite unprepared to say anything on this subject. I may, however, mention some points of interest about this object-glass. As this is the only large object-glass I ever had to make without having to make the mounting for it, I was placed under very peculiar circumstances, not being able to try it on a celestial object until it was at Greenwich, so that the photographs shown on the screen to-night are the first results of that kind I have seen from this object-glass in its photographic position. In Dublin I was only able to use it on our ordinary artificial test-objects. Under those conditions it was necessary to make certain allowances and differences in various directions. It was necessary that the object-glass should have a certain amount of *incorrectness* for near objects in order that it might be perfectly corrected for distant ones, and that of course increased the difficulty of figuring the glass very much. But with regard to the photographic position of the lenses, I was never able to make experiments in this position, and consequently the estimation of the curves so as to give proper results was quite theoretical. I was very much pleased with the results which the Astronomer Royal showed me yesterday. There is a slight want of adjustment yet, but the adjustments have not been of such great difficulty as I anticipated. When these adjustments are made the corrections will be as nearly right as possible. I think the results are very promising indeed.

Dr. Common made some remarks of a technical character criticizing the photographs exhibited.

The President. These photographs, inasmuch as they raise the question of the position of the photographic focus, are very interesting. I am quite unorthodox as to where the photographic focus ought to be fixed. I think opticians have hitherto been wrong as to where it should be. It ought not to be near the focus of the G ray, but nearer that of the F ray, which is a very important fact in photography. The fixing of the focus near G may be accounted for by the fact that formerly iodine plates were used, which are of comparatively slow action, and it will be found that the more rapid the plates the more near will the focus be to that of the F ray in the spectrum. If I were asked to give any advice to the Astronomer Royal on the subject, I should advise that the focus adopted for photography should be that of the ra about midway between the F and G rays of the spectrum.

The Astronomer Royal. Although the Congress of Paris passed a resolution that the minimum focal length was to be that of the G ray, I think the practical question is to get the best possible definition out of the photographs, and though I mentioned G as the minimum focal length, I intend to work from G towards F, so as to see whether we could get better results. I wish to express my hearty concurrence in the remarks the President has made on the point.

Mr. Maunder. The focus in the third adjustment is distinctly on the F side of G, not very far from G, but still very distinctly on the F side.

Sir H. Grubb. When I was making the object-glasses for the Stellar Photographic Survey the results were rather in the direction of what the President has said. It is difficult to determine this in a practical way, therefore I cannot say by how much; but the turning-point of the curve was certainly towards that of the F ray.

Mr. Maunder then exhibited and described some photographs taken at Greenwich of the recent sun-spot and of the magnetic traces showing the disturbances of Feb. 20–28. The sun-spot of Feb. 16–28, Mr. Maunder said, seemed to have caused a great deal of popular interest, although he did not know that it was by any means one of the finest spots, either as to area or as to detail, that had occurred during the present maximum. Unfortunately it was not possible to obtain a photograph of the Sun on Feb. 16 and 17, when the spot came on the east limb; but the 19th was the first day the spot was seen: its area on that day was about 1550 millionths of the Sun's visible hemisphere, or about half the area of the great spot of the year 1892. On the 21st the spot seemed to have attained its maximum extent. The disturbance began about 8 o'clock in the evening of Feb. 20 very sharply; there was a moderate amount of activity until 2 o'clock in the afternoon of the 21st, and the magnets were then at rest for 24 hours. After this quiet time a second outburst took place, beginning just a little before midnight on the 22nd and continuing until 7 o'clock on the 24th, and there was a further outburst in the early morning of Feb. 25. The spot was on the central meridian just about noon of the 22nd, so that the second disturbance was about 10 hours after the passage of the spot over the central meridian. On Feb. 28 an aurora was seen about 7 o'clock in the evening. The spot passed off about midnight on the 28th, and a period of quiescence set in.

Mr. Knobel. Were you able to trace any change in the spot simultaneously with the magnetic disturbances?

Mr. Maunder. I cannot say that from the photographs. We take two or three photographs a day, and that is not a sufficiently continuous record to compare with the magnetic traces in that way.

Capt. Noble. I was very much interested to see how admirably the faculæ were pictured in the photograph of the spot passing off the Sun's limb. I saw it so visually, not photographically; and, judging from what I saw, I never remember to have seen faculæ so accurately reproduced.

Father Sidgreaves. Have you no other auroræ to quote in connection with these matters? There was certainly a vastly finer one than the one you mentioned, a few days previously; I think it was on the 23rd. It was seen at midnight at Stonyhurst in the full blaze of a three-quarter Moon, and it could be seen as it were a great sea with the rollers rolling right up to the zenith.

Mr. Maunder. I think that remark of Father Sidgreaves is interesting because from the size of the spot one would have thought there ought to have been auroræ about that time.

Father Sidgreaves. I do not think I ever saw an aurora so marked; and without the moonlight it would have been wonderful.

Mr. Newall. There was an aurora last night visible at Cambridge after the spot had gone round the edge of the visible hemisphere.

Mr. H. Dennis Taylor then proceeded to read his paper describing the new "perfectly achromatic" object-glass recently invented and perfected by him. Now that photography is so largely supplementing eye-observations in practical astronomy, an object-glass which can be used equally well for either visual observations or for photography without the troublesome operation of adding or reversing and moving of lenses has become a distinct need. This new object-glass not only refracts the photographically active rays about G to precisely the same focus as the most luminous rays, but with regard to the whole spectrum the objective may justly be described as being as achromatic as a reflecting telescope. For it can be shown that the residual colour aberrations likely to remain in the case of even an objective of 2-feet aperture on the new principle, would cause no more detriment to vision than that caused by the colour-aberration of a 1-inch Huygenian eyepiece when used on a reflector whose focal length is 7½ times its aperture. A diagram showing a diametral section of the object-glass was thrown on the screen. It consists of three lenses of three different sorts of glass:—

1st. A positive double-convex lens of a certain baryta light flint-glass, having a refractive index of about 1·564. This is a hard, white glass capable of standing as much weathering as ordinary hard crown.

2nd. A negative double-concave lens of a certain new boro-silicate flint-glass, placed between the two positive lenses. This is the only glass suitable for a negative lens of which it is possible to make large discs. It is a glass of unusual hardness and mechanical strength and exceedingly transparent, except to the violet rays, which it slightly absorbs. Its refractive index is about 1·547. Its durability is guaranteed.

3rd. A positive convexo-concave lens of a certain light silicate crown glass of an exceedingly transparent character and as durable as ordinary hard crown, from which it differs only in having a rather lower dispersive power and somewhat different rationality of dispersion. All three glasses are the productions of the celebrated factory of Herrn Schott and Gen, of Jena. That firm, ever since starting in 1884, have been aiming at producing two glasses of similar rationality of dispersion but of sufficiently different dispersive powers to enable a double object-glass to be made, free from secondary spectrum. Yet this problem seems to be as far from a really satisfactory solution to-day as it was 10 years ago or more. Mr. Taylor, like several other investigators, was irresistibly led to the conclusion that the most perfect achromatism as well as the greatest sum of other advantages would result from the use of three lenses of three different sorts of glass, and the present objective is the outcome of a prolonged investigation of the possibilities afforded by the employment of glass selected from the hundreds of varieties manufactured by Herrn Schott and Gen. Besides being perfectly achromatic, the objective also affords the largest field of view possible to a contact combination of lenses, the lateral images of stars being free from coma, while its curves are such as to realize certain other practical and theoretical advantages touched upon in the paper. The coloured fringes surrounding objects when viewed through ordinary refracting telescopes are entirely done away with in the images formed by this new objective. As regards its performance upon the Moon and planets, the most marked difference, depending on the perfect achromatism of this new objective, is a more black and white or sharper rendering of the fine details, owing to the fact that all the light is used strictly for defining purposes and none scattered over the image in the form of more or less mist. The objective has a ratio of focal length to aperture of 18 to 1; but up to moderate sizes a ratio of 15 to 1 may be attained if specially desired.

Sir H. Grubb. I have listened to the paper with very great interest, and I think the Society ought to be much obliged to Mr. Taylor. Any addition to our knowledge on these subjects is very useful. So far as I am concerned, my interest commences and ends in the theoretical results. It seems to me the whole question is one of the permanence of the glass. Some years ago, probably early in the seventies—but I am not certain of the date—Dr. Common showed me an object-glass made of this Jena glass, and I admired the image and the colour. It was more like an image given by a reflecting telescope than by a refractor; and if the glass had been permanent it would have been very good, but years have gone over and yet we do not hear of any good work being done by it. I am afraid it is a question of permanency. No one would rejoice more than I would if we could get perfect achromatism. I confess I would be slow to employ any glass for large objectives if I did not feel thoroughly convinced it was permanent. I think the test of years is required. If an object-glass is made, and 20 years pass over without alteration, then I consider the time has come to adopt it permanently, but otherwise I should be slow to recommend it. The writer of the paper may be perfectly correct in what he says about the tarnish on the object-glass in some particular case, but my experience has been the opposite of his. My experience is that the tarnish has a very sensible effect indeed upon the amount of light which passes through it. I am very much interested in Mr. Taylor's paper.

Mr. Ranyard. I have recently been at Potsdam, where I saw an objective made of Jena glass. I do not know whether it is the same make of glass as that referred to by Mr. Taylor, but after 6 or 7 years it shows a very distinct white film as seen from the front, and theoretically the amount of light transmitted must be smaller. There must be some loss in this case. No doubt being able to cover the Jena glass with the crown lenses is a very great step in advance, and this perfect achromatism would be a very great step for photographic purposes.

Mr. Taylor. I would like to make a remark anent the observation of Sir Howard Grubb as to having seen in 1872 object-glasses made of Jena glass.

Sir H. Grubb. Pardon me! I did not say that; I said I was not sure of the date, and laid special stress on it.

Mr. Taylor. This could not be, because Herr Schott did not start his factory until 1884. There was another type of borosilicate glass made by Schott which was used by Hastings in America, but that glass could not be made good enough, and the glass I have referred to is a new type. When I was speaking of tarnishing I did not mean actual corrosion of the surface. The tarnish I refer to is a transparent tarnish; it in no way interferes with the surface of the glass. I would not care to use this glass for an exterior lens; but between the other two lenses it is different. We guarantee it is absolutely permanent when it comes between the other two lenses, and I do not know what greater satisfaction we can give as to the continuance of its transparency.

The President. We are all interested in getting a perfectly achromatic object-glass, and if that has been done a great deal has been accomplished. We all recall Mr. Taylor's other very interesting paper, and this seems a second paper on the same kind of subject, the one leading up to the other. He has also promised to give us another paper as to the way in which he separates certain light, and I hope it will be a very interesting paper, because it will show the Society a new step in optical measurements which we have not seen so far.

Prof. Turner then read "Remarks on Mr. Stone's proposed Corrections to the Measure of Time since 1864," by Prof. S. Newcomb.

Mr. Stone. I experience no difficulty in answering Professor Newcomb's paper.

The attempt to disprove my views by a *reductio ad absurdum* is based on the common logical fallacy of a *petitio principii.*

I have proved, or at least profess to have proved, and believe that I have proved, that with the dual systems of time-measurement in use in practical astronomical work the tabular right ascension for the time of a meridian transit can only be accurately found from a certain equation [given on board]. But Professor Newcomb, following the plan at present generally adopted, computes what he calls the tabular R.A. for the meridian transits from an equation which results from the neglect of certain terms which are contained in my equation.

My equation is either right or wrong. But to assume without proof that my equation is wrong and that the equation which is usually employed is right, is simply a begging of the whole question.

If Professor Newcomb can *prove* that, with the dual systems of time-measurement used in practical astronomical work, the equation which he has used is exact, and mine therefore erroneous, there is an end of my explanation of the *per saltum* change in the residual errors (Hansen—Observation) formed in the usual way, which observation has shown to have taken place about 1864, but not a removal of the *per saltum* change itself. On the other hand, if the equation which I profess to have proved is exact, and therefore the tabular R.A. for meridian transits, computed in the ordinary manner, erroneous, there is an end at once of Professor Newcomb's *reductio ad absurdum* argument and the difficulty presented by these residual errors.

[A photograph of a diagram was thrown on the screen showing

1. The errors in the Tables compared in the usual way;
2. When the scale of time-measurement after 1864 was altered so as to be affected with the same errors, if any, as before 1864;
3. When the scale of time-measurement before 1864 was altered so as to be affected with the same errors, if any, as after 1864.]

I will only add that in an experience of astronomical work, now extending over more than thirty years, no such important case of discrepancy between observation and theory or reduction has ever come before me or, I venture to say, any other living man. My explanation can only be disproved by a proof that the equation which I profess to have proved is erroneous; and until this can be done the consequences which result from the necessity of using that equation must be faced and accepted.

The following papers were announced and partly read:—

Rev. T. E. Espin. "The distribution of Stars of Type III., and of Stellar Spectra in Space."

H. C. Russell. "A Seconds Contact-maker for Astronomical Clocks."

W. F. Denning. "Brilliant Detonating Fireball of 1894, Jan. 25."

Prof. S. Newcomb. "Remarks on Mr. Stone's proposed Corrections to the Measure of Time since 1864."

A. M. W. Downing. "Note on the Star D.M. 27° 725."

A. A. Rambaut and W. E. Wilson. "On the Proper Motion of Stars in the Dumb-bell Nebula."

W. E. Cooke. "On the Computation of Star Corrections in N.P.D."

H. Dennis Taylor. "Description of a perfectly Achromatic Refractor."

Prof. H. H. Turner. "Note on Mr. Cooke's paper on the Computation of Star Corrections."

Royal Observatory, Greenwich. "Results of Micrometer Measures of Double Stars made in the year 1893."

Prof. S. Glasenapp. "New Orbit of 9 Argus (β 101)."

The Astronomer Royal exhibited some photographs of stars taken with the 28-inch refractor adjusted for photography, and also some photographs of the recent Sun-spot, and of the magnetic traces, showing the disturbances of Feb. 20–28.

The following gentlemen were elected Fellows of the Society:—

Augustin Stanislaus Ghosh, 28 Convent Road, Calcutta; *Lieut. William H. F. Montanaro,* R.N., H.M.S. 'Canada,' Bermuda; *Walter A. Post,* Newport News, Virginia, U.S.A.; *Alexander William Roberts,* Lovedale, Alice, Cape Colony.

The following Candidates were proposed for election as Fellows of the Society:—

John Briggs, B.A. Cantab., University Tutorial College, Red Lion Square, W.C. (proposed by Dr. R. Bryant); *Rev. Samuel Robert Browne,* M.A., LL.D., Mathematical Master in Bristol Grammar School, Camelot, St. John's Road, Clifton (proposed by F. H. Stevens); *Rev. F. J. Eld,* M.A. Oxon., Whiteladies, Worcester (proposed by Capt. Abney); *Henry Owen,* F.R.G.S., F.R.Met.Soc., Royal Thames Yacht Club, 7 Albemarle Street, W. (proposed by Capt. R. Reynolds); *George C. Pulsford,* Head-Master Royal Hospital School, Greenwich, S.E. (proposed by H. H. Turner); *W. Rickmer Rickmers,* Schwarzspanierstrasse 18, Vienna (proposed by H. Ingall); *William Stewart Stewart,* Levern House, Barrhead, N.B. (proposed by Adam Hilger).

ROYAL METEOROLOGICAL SOCIETY.

The monthly meeting of this Society was held on Wednesday evening, March 21, at the Institution of Civil Engineers, Westminster, Mr. R. Inwards, F.R.A.S., President, in the Chair.

Mr. H. C. Kiddle and Mr. S. R. Lowcock, Assoc.M.Inst.C.E., were elected Fellows of the Society.

Mr. W. H. Dines read a paper on the "Relation between the Mean Quarterly Temperature and the Death Rate." The Registrar-General's Quarterly Returns for the whole of England since 1862 were taken by the author, and the number of deaths in each quarter expressed as a departure per thousand from that particular quarter's average, the value so obtained being placed side by side with the corresponding departure of the temperature at Greenwich from its mean value. The rule seems to be that a cold winter is unhealthy and a mild winter healthy, and that a hot summer is always unhealthy and a cold summer healthy.

Mr. Dines also read a paper on the "Duration and lateral extent of Gusts of Wind, and the Measurement of their Intensity." From observations and experiments which he has made with his new anemometer, Mr. Dines is inclined to think that a gust seldom maintains its full force for more than one or two seconds, and also that the extreme velocity mostly occurs in lines which are roughly parallel to the direction of the wind.

Mr. R. H. Scott, F.R.S., exhibited a diagram showing some remarkable sudden changes of the barometer in the Hebrides on February 23, 1894. At 8 A.M. the reading at Stornoway was 29·39 inches, being a fall of 0·7 inch since the previous day, and at 6 P.M. the reading was 28·58 inches. From the trace of the self-recording aneroid it appears that the minimum, 28·50 inches, occurred about 5.30 P.M., and that the fall during the half-hour preceding the minimum was nearly 0·2 inch, the rise after the minimum being nearly as rapid.

The other paper read was "On the Calculation of Photographic Cloud-measurements," by Dr. K. G. Olsson.

BRITISH ASTRONOMICAL ASSOCIATION.

THE fourth ordinary Meeting of the present Session of the British Astronomical Association was held on Wednesday, 28th February, at University College, Gower Street, Dr. A. M. W. Downing, M.A., F.R.A.S., the President, in the Chair.

The election of 13 new Members by the Council was announced and confirmed by the Meeting, and the names of 11 candidates for membership were read and suspended.

The Secretary read the report of the Variable Star Section for 1892–93, by the director, Mr. J. E. Gore, F.R.A.S. It stated that the work of the section had been chiefly directed to a search for "new" or "temporary" stars in the region of the Milky Way, the discovery of new variable stars, and the observation of known variables. Mr. A. W. Roberts, of South Africa, had reported the discovery of several new variables of short-period in the Southern Hemisphere, some of which had been confirmed by American observers.

Mr. Cuthbert Peek, M.A., F.R.A.S., read his report of the Rousdon Observatory, Lyme Regis, for the year 1893. He reported that the year had been singularly favourable to astronomical work, observations having been made on 191 nights, or about 30 above the average. Observations of the "long-period variable stars" had been regularly carried on, and 537 determinations of magnitudes obtained. A table was appended giving the observed maxima and minima of the stars on the list. The observatory had been frequently thrown open to visitors, of whom there had been more than a hundred during the year.

Mr. Alex. J. S. Adams then read a paper on the "Group of Sun-spots of the Present Month," illustrated by a series of diagrams. Mr. Adams remarked that he has never previously observed such vast changes in so short a period. He also called attention to the coincidence of magnetic disturbances with the passage of the spot across the central meridian.

Miss E. Brown, director of the Solar Section, also contributed a paper on the February Spot-group, calling particular attention to a decided difference in tint in the preceding part of the principal nucleus. The darkness was much less intense, a rounded line of demarcation could be distinctly traced between the two tints, and there were also signs of the formation of a bridge in the same place. Mr. Hale White, a member of the Section, had written to call attention to this uncommon variation in tint. It was probable that the fainter shade was caused by the overlying and invisible faculæ being more dense in the region where the greatest disturbance was taking place. Mr. J. S. Townsend had observed a strong reversal of the C line over the point alluded to. *Mr. E. Walter Maunder* then exhibited on the screen a series of photographs of this group taken at the Royal Observatory, Greenwich, observing that although this particular group of Sun-spots seemed to have caused rather more popular interest than usual, it was by no means of the very largest size, covering only about 2000 millions of square miles, whereas the August 1892 group was upwards of 3000 millions of miles in area.

Mr. A. C. D. Crommelin, B.A., F.R.A.S., then read a paper by *Miss C. Crommelin* and himself on the Solar Eclipse of August 8, 1896, which contained a large amount of interesting information as to the proposed station near Vadsö, on the Varanger Fjord, in Finmark.

The Secretary also read an interim report of the Jupiter Section by *Rev. W. R. Waugh, F.R.A.S.*, the director; also a paper by *Mr. W. Shakleton*, on "A Remarkable Star in Orion." *Mr. Duke* exhibited a new form of Observing Chair with easily adjustable seat.

The President announced that the Council had elected Mr. G. T. Davis a member of their body in place of the Rev. F. Howlett, resigned. Mr. Davis made an earnest appeal for funds for the library, which, thanks to the Council of University College, was now housed in an adjoining room and was available for the use of the members. Mr. Maw supported the appeal and mentioned that Mr. Davis had sent him a substantial subscription, an example he would be happy to follow.

The meeting was then adjourned at 6.55.

The Moon and the Weather.

We do not presume in this note to instruct the readers of 'The Observatory' on a question in regard to which they will or should be above suspicion, that of the supposed influence of the Moon upon the weather, but, in view of the circumstance that various weather-prophets profess to foretell, from the motions of the Moon, the character of our weather for long periods in advance, our desire is rather to reach in this way the many persons in other walks of life who, possessed with a greater or less belief in the Moon's influence, become by these misleading prophets unfortunately strengthened in their erroneous faith. One will resolutely affirm that he has frequently observed correspondence between lunar and weather changes, nay, has himself many times foretold changes of weather with change of Moon which have come to pass. Another, with less of assertion and betraying some sort of desire for information, will more hesitatingly ask: "Well, now, is there anything in it"? but here also the only possible reply will be received with a certain sense of disappointment. A third will plausibly and with greater confidence remind us that "the Moon causes the tides, why not also affect the weather?" Quietly to point out that the tabulation of tides with the Moon's motions for a comparatively short period, say a month, will bring out with sufficient clearness the general fact of a lunar tide, whilst a corresponding tabulation of weather or of any meteorological element carried on for years will yield no tangible result, should prove a staggerer, but it does not satisfy the preconceived notion. Such partial behaviour of the Moon is so unfair. Then comes in the bold weather-prophet, pertinaciously reiterating his infallibility to ready listeners, with the result that, against the voice of the charmer, neither argument nor evidence will avail.

But if we cannot reasonably bring people to understand that there is no ground for believing that the Moon in any sensible degree influences the weather, we may at any rate endeavour in a more practical way to show how little these "lunar" predictions are to be relied on, by comparing them with the result of actual observation.

We are all alike interested in the question of temperature, and especially in knowing the highest point that it daily reaches. Now one of these weather-prophets foretells, among other things, the highest temperature for London on each day for a year in advance, based, it is said, on the movements of the Moon. A comparison of these predicted temperatures with observation should be a crucial test. The discussion of the temperatures for a whole year is a greater work than seems necessary, and the comparison has been confined to four months of the year 1893, the two equinoctial and two solstitial months of that year—March, June, September, and December. The highest predicted temperature on each day in these months has been compared with that registered on the same day at Greenwich, as it appears in the *Weekly Return of the Registrar-General.* The registered Greenwich temperature has been compared also with the *average* highest temperature, as found from the observations of fifty years. It would occupy too much space to give the separate daily comparisons, the general monthly results must at present suffice. In the following table the letters P and A indicate respectively comparison of the actual highest daily temperature with the *predicted* and *average* values of the same.

Month 1893.	Mean daily discordance.		Number of days in each month on which the daily discordance was 10° or more.		Greatest daily discordance.	
	P.	A.	P.	A.	P.	A.
March	7°·5	8°·0	11	11	21°	15°
June	7·8	6·9	11	8	22	20
September	6·2	4·1	5	4	22	13
December	6·1	4·3	8	3	18	11
Sum	27·6	23·3	35	26	83	59

The mean daily discordance is the mean of the separate daily discordances taken without regard to sign.

The result of the comparison is that, as compared with the actual temperature, the discordance of the predicted values is in every way greater than the discordance of the average values, although the predicted values are said to be deduced from consideration of the motions of the Moon.

When the causes of variation of an element are unknown, the average value is the most probable one to expect. But should variations of periodical character be discovered, then values which include such variations should be much more accordant with observation than are the average values. But, as we see above, the predicted values are really less accordant—that is, do not represent observation so well as the average values. So that the introduction of a presumed lunar effect, instead of producing greater harmony, tends to increased discordance. The poor Moon! W. E.

On the Reduction of Astronomical Photographs.

In the 'Astronomical Journal,' No. 310, Mr. H. Jacoby criticizes "Some recent papers on the Reduction of Astronomical Photographs"—among others the note I published in this journal ('Observatory,' vol. xvi. p. 373). His remarks make me doubt whether I have succeeded in rendering the proposed method clear; and as I believe it to be of the first importance that useless labour should be avoided, I think it right to reply at some length. The part of the criticism which seems to me to be evidence of misunderstanding on Mr. Jacoby's part is as follows: he remarks that if x and y be the rectangular coordinates of any star such as they would be if no refraction &c. existed, and x_0, y_0 the actually measured coordinates, then the equations connecting $x, y; x_0, y_0$ are as follows:

$$x=p+ax_0+by, \quad y=q+cx_0+dy_0 \quad . \quad . \quad . \quad . \quad (1)$$

p, q, a, b, c, d being constants for the plate; *but that if the refraction has been allowed for by special correction formulæ these equations become*

$$x=ax_0+by_0, \quad y=cx_0+dy_0 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which the number of constants has been reduced to four. Now it is perfectly true that if refraction and aberration be calculated separately and allowed for, the number of constants in equations (1) can be reduced from 6 to 4; but *it would not be p and q which would disappear.* These are merely the errors of centring of the plate—they contain the refraction at the centre of the plate it is true, but no one has hitherto proposed to calculate this, which affects all stars on the plate alike. It is only *differential* refraction or aberration which need concern us. If these be calculated and applied, then there will be 2 relations between the constants a, b, c, d, which will reduce them from 4 to 2; but p and q must be determined quite independently.

In a paper recently published in the 'Monthly Notices R.A.S.' (vol. liv. p. 11) I have shown that there is no difficulty in applying differential refraction and aberration to rectilinear measures, and that the formulæ are in fact considerably simpler if the coordinates are kept in this form. The method of using rectilinear coordinates does not by any means involve the neglect of such corrections. I am only concerned to point out that if the coordinates are left in the rectilinear form, all discussions are very considerably simplified. Spherical coordinates, and especially those in common use which refer to a moving pole, complicate all the formulæ to an intolerable extent, and suggest distinctions between stars situated near the pole and near the equator which have no celestial significance at all. Such coordinates are a necessity of meridian observation; it must be that catalogues be made for the transit-circle in terms of R.A. and N.P.D. But the simplest way of utilizing our knowledge of star-places up to the present is as follows:—Bring up the places of the few thousand known stars to 1900·0, and then convert them into rectangular coordinates on plates taken ideally according to the resolutions of the Conference. Such coordinates will be connected with the actually measured coordinates on the plates by linear relations, the constants of which they will help to determine. It seems almost certain that the places of known stars must be brought up to 1900·0 in any case, for this is bound to be a most important epoch. Tables which can be easily constructed for each zone will facilitate the expression in ideal or standard rectangular coordinates. The alternative (as hitherto proposed) is to convert the coordinates of the million or so of stars measured on the plates into R.A. and N.P.D.

Since writing the brief note criticized by Mr. Jacoby, I have had several opportunities of testing practically the method of rectilinear coordinates for discussing photographs, and my confidence in its merits increases daily. I think it will become clear to those who will give it a trial that nothing whatever need be lost by its use, either in accuracy or clearness, while the gain in convenience and concision is very great. Consider, for instance, the objection that parts of the constants p, a, b in the equation

$$x=p+ax_0+by_0$$

can be calculated separately, being due to refraction and aberration, or known defective scale value or orientation; and should therefore be so calculated and applied to the measures. This involves the correction of every star. But if the coefficients be deduced from the plate itself, they can be at once compared with the theoretical values which they should have, and the agreement of theory with observation, or the existence of some unsuspected source of error, may be thus made clear.

Again, in the case of several plates of the same region—say the Pleiades—if the spherical coordinates of the Pleiades are once reduced to rectangular coordinates, the measures on all the plates are immediately comparable with them. The alternative process is to laboriously reduce all the measures on all the plates to spherical coordinates, by formulæ which differ slightly in every case.

H. H. Turner.

Large-scale Photographic Maps of the Moon.

During the year 1890 Dr. Langley, Director of the Smithsonian Institution, sent a circular to various public and private observatories regarding the making of a photographic map of the Moon. This circular is printed in the 'Observatory,' 1890, Vol. xiii. pages 403–404. Dr. Langley's circular suggests a scale of 1 mm. = 1″ for such a map, which would make the Moon's diameter about 1·9 metres. Highly successful experiments in enlarging the focal negatives of the Lick Observatory have been made during the past two years by Baron Albert v. Rothschild of Vienna, Mr. V. Nielsen of Copenhagen, and by Prof. Weinek and Dr. Spitaler at Prague; and these experiments have shown that it is perfectly practicable to produce such a map as Dr. Langley describes by directly enlarging the focal negatives taken at Mount Hamilton. It is also distinctly advantageous to make such enlargements. That is, all features on the Moon whose angular dimensions are small and whose visibility depends upon good definition (as small crater-pits, narrow rills, &c.) are better seen on the enlargements than in any other way. This is entirely true even for the latest enlargements made by Prof. Weinek, in which the Moon's diameter is about 10 English feet; and it is not only true for certain selected parts, but it is true for all regions suitably illuminated. Specimens of this work (silver prints) have been sent to various institutions, as the Royal Astronomical Society, Astronomical Society of France, &c., and a set of such prints is now displayed at the Midwinter Fair in San Francisco. An examination of any of these specimens will show the distinct advantage spoken of. This advantage is preserved to a great degree in an autotype reproduction of one of Prof. Weinek's enlargements (the crater Tycho) which is to form a part of Vol. iii. of the 'Publications' of the Lick Observatory, now nearly ready for the press. Those features of the Moon which depend for their visibility upon accenting the faint *contrasts* of the original negatives (as terraces, light streaks, &c.) are not quite so well seen in the autotype plates as they are in the silver prints, or, of course, in the glass. It may now be said that the problem suggested by Dr. Langley's circular is fully solved, and that the desired map can be made.

The only question remaining is what scales will be most useful to astronomers. It is my own opinion that, in the first place, an atlas of the Moon to the same scale as Maedler's and Lohrmann's map (3 Paris feet) is imperatively required. Such an atlas will serve nearly all of the general purposes for which a map of the Moon is commonly required. Owing to the comparatively small enlargement (some 7-fold), the atlas sheets can be made to include quite large areas of the Moon without losing the fainter contrasts of the negatives. Each region of the Moon must be shown under two different illuminations—morning and evening Sun, for example.

It would be very convenient to have a second atlas on the scale of Schmidt's great map (6 feet to the diameter) for purposes of comparison. I can see no advantage in changing this scale to the slightly smaller one of 1 mm.=1″. It is also highly important to have a complete atlas on the largest *practical* scale; *i. e.*, on the largest scale which presents a distinct advantage. The scale is about 10 feet. Prof. Weinek's prints, above referred to, show known features of the Moon with excellent definition and relief, and they disclose a very great number of new features (*i. e.*, those hitherto unmapped and unphotographed). Nothing is shown, of course, which is not in the original negative, but what is in that negative is made obvious.

It is hoped that the 3-foot and 10-foot atlases will be made in the near future, as soon as the necessary expenses can be provided for. At any rate, the scientific problem is now solved and only the financial one remains.

Lick Observatory,
1894, Mar. 5.

EDWARD S. HOLDEN.

Selenographical Notes.

THE CRATER-ROWS WEST OF COPERNICUS.—Most observers are familiar with these features to the extent of utilizing them for testing the steadiness of the air or the definition of their telescopes; but they merit a much closer and extended examination than is involved in this. Webb, in an interesting article ('Intellectual Observer,' vol. xii. p. 438), was the first to draw special attention to the structural peculiarities of the principal chain of craters running northwards from the north-eastern side of Stadius. Observing them with his 9⅓-in. With mirror on Feb. 23, 1866, the terminator lying beyond Tycho and Plato, they reminded him of "a mole-run with holes in it," a simile which, though a very homely one, will commend itself to anybody who observes them under a low morning Sun. During the years 1885–87 these objects, together with the Stadius region generally, were carefully studied and observed by the members of the Lunar Section of the Liverpool Astronomical Society, and the results incorporated in a report which appears, with an illustrative diagram, in vol. v. pt. 8, of the 'Journal' of that Society. These observations, while fully confirming Mr. Webb's records, show that in addition to the comparative coarse chain of craters familiarly known as "the crater-row west of Copernicus," there exists, in a line running roughly parallel to it on the west and at no great distance from it, another chain consisting of very much smaller depressions of a somewhat different character and much more numerous.

Observing Stadius between 6^h and $8^h 15^m$ on December 15, 1885, with a power of 340 on my 8½-in. Calver reflector, the morning terminator bisecting the ring of Copernicus at 7^h, I noted a long dusky streak extending in a northerly direction from a point some distance to the north of the very inconspicuous north border of Stadius, and lying closely parallel to the crater-chain. For some time no detail whatever was remarked in connection with this feature; but as sunrise advanced and definition improved, it became evident that the summit of a ridge, whose flanks were represented by the dusky streak, is crowned by a number of very minute craters, very much smaller than any of the constituents of the principal chain. Eight were certainly counted and others suspected on this occasion, which was especially favourable for the observation of minute detail. At 8^h 30^m May 1, 1887, the east long. of the morning terminator being about 16°, this subordinate crater-row was observed under still more favourable conditions with the same power. It was traced from a large depression which marks the northern end of the east wall of Stadius, much further in a northerly direction. Fourteen craters could be easily counted on the summit of the ridge. It may assist observers who wish to see these features, to know that a line from the crater near the southern end of the mountain-arm extending from Eratosthenes to the western flank of Stadius, through Stadius B, aligns with the large depression at the southern extremity of the crater-ridge in question.

At 9^h 10^m March 15 this year, and at about the same hour on the following night, I again obtained satisfactory views of the ridge and of some of the little craters on its summit. On the latter date two short and very delicate clefts were observed crossing the plain north of Stadius, the more southerly running in a westerly direction from the north end of the ridge towards the mountain group east of Eratosthenes and the other, close by, trending towards the east. They may represent very minute confluent craterlets, but they resembled true rills.

The principal crater-row, which Webb describes so accurately, follows a curve concave towards the east. At an early stage of sunrise, when the attenuated eastern border of Stadius is easily visible, this section of the wall and the chain of depressions are seen to form an S-shaped curve, there being only a short breach of continuity between the row of craters on the border and those on the "mole-run." On March 16 I counted eight depressions on this raised bank. It terminates somewhat abruptly on the north, but it is succeeded by another chain of much more delicate craterlets, which also trend in a northerly direction, curving slightly towards the west.

Stadius and the surrounding region is so inconspicuous, except under a very low angle of illumination, that it is hardly to be wondered at that even so acute an observer as Mädler overlooked this ghostly ring for some years, and only discovered it when he was searching for something else. As a known object, however, it can be traced under a high light. On April 15, 1886, 9^h, when the eastern wall of Herodotus was on the morning terminator, I could not only see the outline of the border, but many of the craters in the interior and on the wall, the crater B on the north of the formation, and many of the small depressions surrounding it. Five of the craters on the principal chain were also easily detected. On a subsequent occasion I saw all these features nearly as plainly at a still later phase, when the region was traversed by the rays from Copernicus.

Beaumont House, Shakespeare Road,
Bedford, 1894, Mar. 19.

THOS. GWYN ELGER.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Dr. Mahler's attempt to fix the Date of the Exodus by Astronomy.

GENTLEMEN,—

Prof. Sayce, in p. 242 of his recent work 'The Higher Criticism and the Verdict of the Monuments,' says:—"The reign of Ramses II. had the long duration of sixty-seven years. The date of his death has recently been fixed by Dr. Mahler upon astronomical grounds in 1281 B.C." This date is about twenty years later than that which was considered to be most probable on historical grounds by Brugsch. But it seems to me that Prof. Sayce has somewhat misunderstood Dr. Mahler, whose astronomical arguments in his 'Biblische Chronologie' (published at Vienna in 1887) are certainly ingenious, but scarcely convincing.

He has found that an eclipse of the Sun was total in the Egyptian Delta on the 13th of March in the year A.D. −1334, = B.C. 1335, the totality of which, he thinks, did not extend to the district of Goshen, where the Israelites were. Hence he attributes to this cause the plague of darkness which took place shortly before the Exodus; and as no eclipse could produce a darkness on three successive days, the statement that the Egyptians did not rise from their places during that time he refers simply to their fright at the eclipse on the first day, which would surely be attributing to that people greater cowardice at a celestial phenomenon than is usually felt even by the most barbarous nations, who soon recover their spirits when the Sun's light returns.

But, however that be, the plagues and the subsequent exodus of the Israelites from Egypt certainly took place some time after the death of Ramses II.; and if we accepted Dr. Mahler's view respecting the eclipse, we should place that king's death about B.C. 1340, earlier, not later, than the date assigned by Brugsch.

Dr. Mahler's theories enable him to be very precise in his dates. Thus, fixing the miraculous darkness by a solar eclipse on March 13, he gives the exact time of the Exodus as the day of Full Moon following, or March 27 in B.C. 1335. But both this and several other points in his 'Biblische Chronologie' are, as I remarked before, rather ingenious than convincing. My chief reason for referring to the matter is the widely diffused study of Prof. Sayce's book. The passage which I have quoted (and a similar one in page 220) would lead to the impression that astronomy had decided beyond a doubt that the Exodus took place some years later than B.C. 1281—for it certainly did not occur until after the death of Ramses II., the principal Pharaoh of the oppression.

Yours faithfully,

Blackheath, 1894, Mar. 9. W. T. LYNN.

Annular Eclipse in India.

GENTLEMEN,—

On the eve of a narrowly annular eclipse of the Sun across the Indian peninsula one is induced to look backward to the last one that was annular in that country. Speaking of the eclipse of June 6, 1872, the Report of the R. A. S. presented the following February refers to Mr. Pogson's observations at Madras "in recognizing the reversal of the solar spectrum, a phenomenon which has hitherto been only witnessed during total solar eclipses." The report goes on to remark that some observers could not see this during the total eclipse of 1871, but that "the observation of the reversal of the spectrum during an annular eclipse is decisive of the matter." The track of the coming eclipse seems somewhat interesting, for while it enters the Indian coast a long way south of Bombay with a duration of nearly half a minute of annularity, it contracts to about 8 seconds duration only in passing between Calcutta and the Bay of Bengal. With the Sun on the meridian, which seems to fall in Mongolia, where we unfortunately cannot expect observers, the duration of annularity, according to the American 'Nautical Almanack,' is 0·9 seconds only, and by Oppolzer's method would be total for 4 seconds. At the next return of this eclipse, when the central line seems to go right across Paris, the Sun's diameter will be a trifle less, but totality could only last in the neighbourhood of the French capital a very few instants.

Melplash Vicarage, Bridport,
1894, Mar. 6.

Faithfully yours,
S. J. JOHNSON.

A perfectly Achromatic Telescopic Objective.

GENTLEMEN,—

Will you kindly allow us space in your magazine to reply to some remarks made by Sir Howard Grubb and Mr. Ranyard in the discussion, at the Royal Astronomical Society's Meeting on the 9th inst., on Mr. H. D. Taylor's paper describing a perfectly achromatic telescopic objective?

Sir Howard Grubb stated: "About the year 1872 or 1873 Dr. Common showed me an object-glass made of this Jena glass, and I admired the image and the colour." "This Jena glass" is a phrase which can have but one meaning, viz. the glass employed by Mr. Taylor; and we are in a position to state that Dr. Common never had in his possession an objective constructed of such glass, and as a mtter of fact no Jena glass of any kind was made before July 1885.

Sir Howard Grubb also remarked: "If an object-glass is made, and 20 years pass over without alteration, then I consider the time has come to use it permanently, but otherwise I should be slow to adopt it." We have consulted eminent chemists as to the causes of tarnish and corrosion, which undoubtedly are present in some varieties of glass; we have experimented ourselves, in many ways; we have been to Jena, and interviewed the heads of the Jena factory; we have seen a surface of the Borosilicate Flint (0·164) which was polished in 1886, and has been lying about in Dr. Schott's laboratory without any protection ever since, and which is, with the exception of some scratches, for all practical purposes as good as the day it was polished; and we are entirely satisfied that with ordinary precautions the borosilicate flint is as durable as the ordinary flint hitherto used in the construction of objectives, and as a matter of business we are prepared to guarantee the durability.

Mr. Ranyard referred to an object-glass which he saw at Potsdam made of Jena glass, which showed a distinct white film as seen from the front. We know of this glass, but it is of quite a different construction from Mr. Taylor's. It was made by Bamberg from two varieties of Jena glass—Dense Barium Phosphate Crown S. 30, described in Dr. Schott's catalogue as "Not very hard relatively," and a Borate Flint either S. 7 or S. 8, to which in the same catalogue is appended the remark "Must be protected"; both these glasses have been found unserviceable. Prof. Hastings has also employed in his combination a type of flint-glass which Dr. Schott has ceased to make on account of its unserviceability; but to condemn the whole of the 76 varieties of glass produced by the Jena firm as non-durable on account of the non-suitability of some of them for certain purposes is obviously unreasonable.

To the researches and experiments of Dr. Schott, Prof. Abbe, and Dr. Czapski the astronomical world is indebted for having made the production of an achromatic telescope not only a possibility, but a fact; and we take the opportunity of publicly acknowledging the great obligations we are under to them.

Buckingham Works, York,
1894, Mar. 22.

Your obedient Servants,
T. COOKE & SONS.

The British Astronomical Association.

GENTLEMEN,—

I have read your report of the remarks I made at the Annual Meeting of the Royal Astronomical Society with a feeling alike of pain and dismay, inasmuch as, if it really fairly represented my utterances with reference to the British Astronomical Association, it must seem to anyone who was not present at Burlington House on the 9th ult. that the whole gist of my observations was to depreciate what I most sincerely honour and admire, and in which I take the keenest possible personal interest. Called upon by the President, at an instant's notice, to reply to Mr. Knott, I began by giving my experience as to the crowded state of our afternoon meetings at the time when I had the great honour and pleasure of presiding over the Association, and I went on to contend that, if some of our members, of comparatively scanty means and leisure, could find the time and opportunity to crowd our meeting-room at 5 P.M., *à fortiori*, those who were much more their own masters might, once a month, submit to some slight personal inconvenience for the sake and love of science. Undoubtedly the words "lower social stratum," "social position," &c. are, in any such connection, the veriest solecisms; inasmuch as all I meant to convey was that some members of the British Astronomical Association were, in one sense, less independent than a large proportion of the Fellows of the Royal Astronomical Society, and were, consequently, making, quite cheerfully, a much heavier personal sacrifice than the latter were called upon to endure for the advancement of Astronomy. I regret extremely that you should have thought it necessary to report my stupid joke about "a mixed lot," which reads like a serious allegation on my part, and not, as it was intended and was taken by the Meeting to be, a jest pure and simple. At all events, "mixed" or unmixed, there is assuredly no one single member out of our 700 or 800 who is prouder of his connection with the British Astronomical Association, or appreciates it and its admirable work more truly, earnestly, and highly, than

Yours faithfully,

Forest Lodge, Maresfield, Uckfield,
1894, Mar. 12.

WILLIAM NOBLE.

[We hope that no member of the above-mentioned Association has felt hurt on reading our report of Capt. Noble's remarks. If so the report is certainly to blame, for no one who heard Capt. Noble speak could possibly have thought that he intended to say anything offensive.—EDS.]

PUBLICATIONS.

POND'S DOUBLE-ALTITUDE OBSERVATIONS, 1825–35, BY MR. S. C. CHANDLER.—In pursuance of his investigation of the variation of latitude, Mr. Chandler found the necessity for some observations prior to the year 1840, about which epoch it will be remembered the Pulkova Prime-Vertical Observations, already used by Mr. Chandler in his investigations, were made, which embracing a longer span of time than the Pulkova Observations would give a better determination of the length of the period and the other constants of the latitude variation formulæ. Mr. Chandler has found these required data in Pond's double-altitude observations made at Greenwich with the two mural circles, Jones's and Troughton's, in the years 1825–35, and begins, in the 'Astronomical Journal,' No. 313, a series of papers on the reduction of these observations, which he is effecting, in which he expresses his high admiration for Pond's methods and work, and his appreciation of their value for the purpose of his investigation; he says: "The rich mine of stellar measurements thus provided has remained practically unworked for sixty years, only now to yield its priceless information and to emphasize Bessel's profound characterization of Pond's work as the '*ne plus ultra* of astronomical observation.'" Pond's method of double-altitude observations may not be very well known; it is briefly explained in this paper as follows:—"A star, A, at a given culmination was observed directly with one instrument and by reflection with the other. Another star, B, was observed directly with both instruments. Half the difference of the circle-readings for A gives the apparent altitude affected by half the difference of corresponding circle-readings of the two instruments. Half the difference of the circle-readings for B gives directly the half difference of circle-readings, which, applied to the result for A, gives its absolute apparent altitude affected only by the mean flexure of the two instruments at that altitude. The polar stars observed at both culminations give the absolute latitude which completes the data for finding the horizontal points and index errors of both instruments and thence the absolute declination from each observation with each instrument, subject of course to flexure and division-error and to the variation of latitude."

Mr. Chandler has selected 36 well-known stars from Pond's observations, well distributed both in R.A. and N.P.D., observed in all at 7176 culminations or 14,352 times with both instruments; these observations of altitude have been reduced to the epoch 1830·0, using the Pulkova constants of precession and nutation, 20″·500 as the constant of aberration, Boss's proper motions, except in one particular case, and Bessel's refractions, subject to a modification hereafter referred to; these reduced altitudes have then been converted into declinations by applying a provisional value of the latitude 51° 28′ 38″·27, obtained from the observations of Polaris. There are thus 7176 measures of declination of 36 stars, free, so far as this investigation is concerned, because the telescopes were not shifted on the circles throughout the eleven years, from errors of division and flexure. Mr. Chandler has guarded against any refraction error arising from imperfection in the meteorological instruments or their exposure by making a determination of the thermometer coefficients from the observations themselves.

The present instalment, after giving these preliminary details, concludes with the results of a discussion of the accidental errors of the observations, from which a probable error of a single observation ±0″·382 is deduced. A table is given comparing the results of this discussion with similar results for other instruments, the Paris Gambey Circle, the Greenwich Transit Circle, the Leyden Meridian Circle by Pistor and Martins, and others. Mr. Chandler says:—"The result of this discussion of accidental error is to show that Pond attained, with these instruments and this method, a degree of refinement in this respect which not only excels that of any similar work contemporaneous with it, but which has been scarcely surpassed anywhere or at any time. In the subsequent presentation of the discussion of the astronomical constants—including those of the variation of latitude, the aberration and the nutation, as well as stellar parallaxes and declinations, deduced from this work—the probable freedom of these mural circles from systematic error will appear in an equally favourable light." . . . .

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ANNUAIRE DE L'OBSERVATOIRE ROYAL DE BELGIQUE, 1894.—The edition of this publication for 1894, which has lately reached us, contains, as usual, an astronomical almanac computed for Brussels, the times of rising and setting of the Sun and planets being given in Belgian official time—which is now the same as Greenwich time,—and besides other facts of Astronomy and Physics gives information about things not usually associated with an observatory, such as the price of cattle in Belgium and the number of passengers between Ostend and Dover; in fact, the work is a useful statistical account of the state of the country. A large part of the book is taken up with memoirs by M. Folie on the variation of latitude and cognate subjects. It may be remembered that M. Folie had been originally inclined to doubt the reality of the variation of the height of the pole, but was inclined to believe in its apparent variation as due to initial nutation, the amount of which he considers not sufficiently appreciated. But in reducing the observations for latitude made at Honolulu by M. Marcuse he found that they could be satisfied by a variation having a period of 398 days, and he now thinks that the accumulation of snow in the northern hemisphere during some months of the year, combined with the hypothesis of a fluid interior of the globe, supplies a dynamical reason for a movement of the axis of inertia, in a period of 365 days, that 427 days is the most probable period for the initial nutation, and that a combination of these two effects gives the period of 398 days, more or less, referred to above. The other papers in the volume are essays on the constant of aberration, on the determination of constant of nutation, and on the complete reduction of star places according to M. Folie's hypotheses.

DIAMETER OF VENUS.—M. Ambronn gives in the Ast. Nach., No. 3204, his measures of the diameter of Venus made with the great heliometer at Göttingen. The observations were made shortly before sunrise and shortly after sunset in the early part of 1892. In all there are measures on 34 different days. M. Ambronn appends other determinations for comparison, and we reproduce here:—

E. Hartwig,	from Oxford observations	17″·582
„	from observations with the heliometer at Breslau	17 ·67
„	from observations made by Kaiser with Airy's double-image micrometer ..	17 ·409
„	from 9 measures in Bahia Blanca....	17 ·406
B. Peter,	from 2 „ „	17 ·216
F. Küstner,	from 2 „ Punta Arenas ..	17 ·312
A. Auwers,	from measures made during transits of Venus......................	16 ·801
L. Ambronn,	Göttingen heliometer..............	17 ·711

THE VAULT OF HEAVEN *.—There are not many elementary text-books on Physical Astronomy—the Astronomy of the Spectroscope and Camera—so we gladly welcome this work by one who has had practical experience of these modern instruments, and tells what he has learned in a pleasantly accurate style. The book is not all physical, however. Nobody writing a book on elementary astronomy seems able to resist explaining—with a diagram—how to draw an ellipse, nor to refrain from exhibiting the relative sizes of the planets by an illustration more or less novel; but these little weaknesses will be forgiven on reading excellent explanations of the principles of spectroscopy, the chemistry of stars and nebulæ, and an exposition of the meteoritic hypothesis in an untechnical form, which will be appreciated by the average man, who likes to have a popular idea of the astronomical theories of the day, whether he believes them or not. There are also some good reproductions of recent results of celestial photography, the Andromeda Nebula and the Pleiades cluster by Dr. Roberts among others. We can recommend this book for popular reading.

THE VOICES OF THE STARS †.—This is the second edition, under a new title, of a book of a certain class, a sample of which we do not remember to have seen lately. The book is divided into ten chapters, dedicated respectively to Light, the Observatory, or to some member of the Universe, each beginning with astronomy, pure and simple, and ending with theology, the astronomy being used, in sometimes a forced way, as a text on which to hang a sermon. The astronomy is sufficiently good. The author in his preface modestly disclaims any scientific qualification, and states frankly that his Astronomy is compiled from various well-known books, to which he gives frequent and useful reference, and, as we have said, this compilation is well done; but why, oh why! should Astronomy, of all the sciences, be chosen as the one on which to hang moral discourses; surely this relic of past years should be

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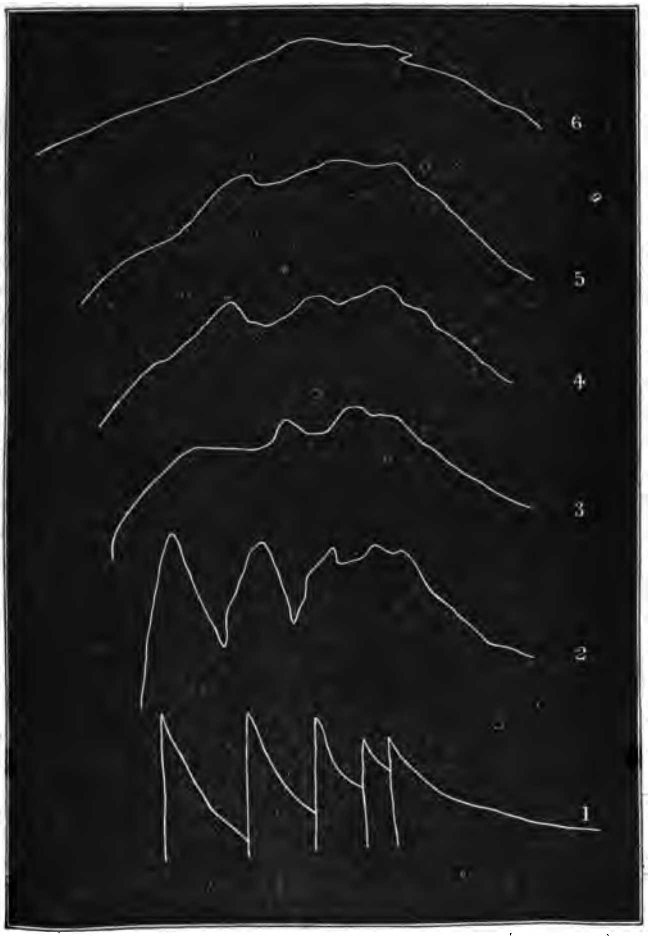
* 'The Vault of Heaven,' by R. A. Gregory, F.R.A.S. Methuen & Co. London, 1893.

† 'The Voices of the Stars; or the Supernatural revealed in the Natural Science of the Heavens.' By J. E. Walker, M.A. (Elliot Stock.) London, 1894.

put aside in the category with astrology and planet ruling! In fact, in one case, our author seems to have some belief in Astrology, for he takes the myriad of small meteors which go to make up Saturn's rings as symbolical of the myriad earthly wickednesses circling about Ill-fortune—using the astrological signification of the planet. We wait for the book on Electricity treated from a theological standpoint.

NOTES.

COMET NOTES.—In Ast. Nach. Nos. 3214, 3217, there are two interesting papers by H. Kayser on cometary spectra. Their



general agreement with the carbon spectrum was early recognized, but there are some important differences, viz.:—

(1) The bands in the carbon spectrum have their light maxima at the red end, those of comet spectra have theirs in the middle, *i.e.* the wave-length of the maxima are smaller in the latter.

(2) In the carbon spectrum the first maximum is the brightest, in comet spectra the second.

(3) The wave-lengths of the light maxima appear to vary with the brightness of the comet.

After discussing and rejecting two explanations of these anomalies given by Vogel and Hasselberg, the author gives his own, which is that they are all due to the wide slit used in visual work on comet spectra, and consequent impurity of the resulting spectra. Thus in the diagram (p. 153) if the lowest curve be the true light curve, with a very narrow slit, of one of the groups of bands in the carbon spectrum (the red end being towards the left) the other curves going upwards show the apparent spectrum with a wider and wider slit. It will be seen that the light maxima are pushed more towards the violet the wider the slit, also that with a wide slit the second maximum becomes brighter than the first; this explains the first two anomalies: moreover, the width of the slit used would be less the brighter the comet, which would explain the third anomaly. He therefore requests that in future observers should note the width of slit and dispersion used in work on comet spectra. He considers his theory confirmed both by laboratory experiments and by the fact that the beautiful photographs of comet spectra taken at Mount Hamilton by Prof. Campbell, with a much narrower slit than is possible in visual work, give results practically identical with the carbon spectrum.

A faint comet with a short tail was discovered by Mr. Denning on the evening of March 26, its place at 9^h 30^m P.M. being R.A. 9^h 54^m 37^s, N. Dec. 32° 13′. It has been observed at Greenwich and elsewhere, but no orbit is yet to hand; the following is a rough ephemeris for the next few days at 9^h 30^m P.M.:—

	R.A.			N. Decl.	
	h	m	s	°	′
April 4 ……	10	25	10	27	18
8 ……		36	12	25	6
12 ……		45	40	22	55
16 ……		53	34	20	43

Herr Schulhof has computed the following search ephemeris of Tempel's Comet (1873 II.), whose return this year was referred to by Mr. Lynn in the January number:—

	R.A.			S. Decl.			R.A.			S. Decl.	
	h	m	s	°	′		h	m	s	°	′
April 1..	21	38	32	11	58	May 3..	23	27	50	5	55
9..	22	6	32	10	34	11..	23	53	39	4	20
17..	22	34	10	9	4	19..	0	18	40	3	49
25..	23	1	18	7	30						

The probable error of the ephemeris is about 4^{m} and $5'$. Throughout this period the comet only rises some two hours before the Sun in this country, but is more favourably situated for observers in the southern hemisphere. A. C. D. C.

Minor Planet Notes.—The following have been discovered in the last month:—

AX	March 1	Wolf, Heidelberg.
AY	1	„
AZ	5	Courty, Bordeaux.
BA	7	Charlois, Nice.
BB	8	„
BC	24	Bigourdan, Paris.

The date of the discovery of AW was erroneously given last month as Feb. 18; it should be Jan. 30.

AX, AZ were of magnitudes 9·5 and 10 respectively, being considerably brighter than most recent discoveries.

Solar Prominences in 1893.—Prof. Tacchini, of the Collegio Romano, has lately published in the 'Comptes Rendus,' Vol. cxvi. No. 19, Vol. xcvii. No. 24, and Vol. xcviii. Nos. 8 and 11, the results of his observations of the Sun during the year 1893; the average number of prominences seen during each month and their average height is given in the following table:—

Month.	Mean Number.	Mean Height.	Month.	Mean Number.	Mean Height.
		″			″
January	8·12	41·5	July	6·23	37·4
February ..	9·00	37·5	August ..	8·73	36·3
March	9·10	38·0	September .	6·77	36·5
April	11·58	39·3	October ..	5·82	36·2
May	6·52	40·1	November .	5·00	34·7
June	5·81	38·8	December .	6·48	35·5

Mean for 1893 .... Number 7·58 .... Height 37″·7
„ 1892 „ 9·19 „ 39 ·6
„ 1891 „ 7·06 „ 40 ·4

The average number of days of observation per month in 1893 was 23, ranging from 13 in November to 29 in March and August.

The prominences throughout the year have been most frequent in the southern hemisphere of the Sun, as, indeed, have the other solar phenomena, spots and faculæ. The most favoured region for prominences appears to have been between the solar latitudes 50° and 70° south, whilst that for spots and faculæ was in the zones between 10° and 20° in both hemispheres.

The Proposed Change in the Astronomical Day.—As stated in our notes of July last, a committee, with Mr. Sandford

Fleming as chairman, appointed by two Canadian Institutions, invited the opinions of astronomers as to the advisability of adopting mean midnight as the beginning of the astronomical day. In answer to the circular sent out 170 replies have been received, of which 107 are in favour of the change and 63 against. Dividing these replies according to the countries from which they come, it is seen that Germany, which supplies 31 of the adverse votes, is the only country decidedly against the change. Holland, Norway, and Portugal each send only one vote, which is adverse in each case, and the Swiss voters are equally divided; but Austria, Australia, Belgium, Great Britain, Canada, Colombia, France, Greece, Italy, Jamaica, Madagascar, Mexico, Roumania, Russia, Spain, and United States send majorities in favour of the change.

Mr. Sandford Fleming in the course of much travelling during the past year has consulted many captains of British ships on the subject, who are unaminously in favour of the proposal.

INVISIBLE DARK STARS.—The remarks of Mr. Burnham on ζ Cancri in the 'Monthly Notices,' April 1891, and his more recent paper on τ Cygni and ϵ Hydræ, called forth a review of the theory of dark companions from Prof. Seeliger in the Ast. Nach. 3165. Mr. Burnham says his last word on the subject for the present in 'Astron. and Astro-Physics' for Dec. 1893. His present position may be expressed thus:—Mr. Burnham pointed out (M. N. vol. li. p. 388) that the observations of many other double stars show irregularities, which might equally well be explained by the hypothesis of a dark companion, and therefore objects to the theory on the ground that it proves too much. He assigned as a reason for the irregularities in the case of ζ Cancri, which recur at periods more or less uniform, first that the centre of gravity of A and B is probably not at the point midway between the stars, which would help to explain the observed motion if it be real; and secondly that it may not be real and that the observed irregularities are merely errors of observation, caused especially by the difficulty in bisecting the line AB, and he gave reasons why an error due to this cause should be periodic. Mr. Burnham suggested that differential measures of C with reference to neighbouring stars should be made with a meridian instrument, as being less liable to these errors of observation. He himself began such a series (M. N. vol. liii. p. 40), but has not now the opportunity of continuing these, but thinks that there is nothing more to be said on the subject until further similar measures are forthcoming.

FREE PUBLIC OBSERVATORIES.—In the February number of 'Astronomy and Astro-Physics,' Mr. W. W. Payne has an article on the advisability of establishing in towns free Observatories for the instruction and entertainment of the public, and refers to a meeting of the Boston Scientific Society at which this subject was seriously discussed. This sounds nice but Utopian. There seems to be some chance of difficulty in working out this scheme. We assume, but Mr. Payne does not say so, that these luxuries are to be paid for out of the public rates; and remembering the popular feeling on School Board matters and public libraries, we fancy that, in England at least, the promoters will encounter some opposition. The actual object is not quite plainly stated; if it be to provide any would-be student with a suitable telescope to devote to any research he may choose, the demand at the onset is likely to exceed the supply. If it is merely to provide a telescope with which the general public may take turns in having a look at Jupiter and Saturn, the gain to the community would probably be disproportionate to the trouble in arranging the queue. There is a third alternative, that the free Observatory is merely to be used as apparatus for illustrating lectures in practical astronomy delivered to an evening class, and in this way it might be made of service; but in any case would not the ratepayers who are students of chemistry or electricity expect to have their hobbies also paid for out of the public purse?

Referring to the note on novelists' Astronomy in our last number, Mr. H. S. Davis, of Columbia College, N.Y., writes:—"I desire to call attention to chapter lxi. of that most delightful novel by Blackmore, 'Lorna Doone.' The passage referred to is '.... and though there would be a Harvest Moon, Ruth agreed with me that I must not keep my mother waiting, with no idea where I might be, until a late hour of the night.' Two or three pages farther on we have: 'Now, through the whole of that long walk—the latter part of which was led by starlight, till the moon arose—I dwelt, in my young and foolish way, upon the ordering of our steps by a Power beyond us.'

"As the Harvest Moon is a full Moon, and therefore rises at sunset, it is hardly likely that there was much starlight to lead his steps. Furthermore, if the author would have us infer that it was a *long walk ending late in the night*, as implied by the first passage, obviously the mistake is intensified, not mended, by the second paragraph."

The season of Easter frequently brings to Greenwich correspondence relating to dates of Easter Full Moons or otherwise connected with the calendar. This year a correspondent enquires about the date of the Paschal Full Moon in the year A.D. 31, which year seems to have been rather an extreme case in a certain respect. In this year Easter Sunday, according to De Morgan and other authorities, fell, as in the current year, on March 25, because Saturday the 24th was the fourteenth day of the Moon (New Moon happened in the evening of Sunday, March 11), which is taken as the day of Full Moon for ecclesiastical purposes, but *the actual Full Moon did not happen until the morning of Tuesday, March 27.* The day of real Full Moon being therefore the third day after the ecclesiastical day of Full Moon, this large difference being due to the facts that New Moon happened late in the evening, and that the period between New Moon and Full was considerably larger than half the lunation.

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61 Cygni.—In the autumn of 1890 M. Wilsing, with the aid of the Potsdam photographic refractor, took a series of photographs of this well-known system. A careful study of the plates shows them to give distance measures accordant with the best micrometric measures; but the discussion of the parallax was not satisfactory, owing to an apparent periodic variation in the distances of about 22 months. M. Wilsing is of opinion that the cause of these perturbations is the existence of one or more companions.

We regret to announce the death, at the early age of 31, of Mr. B. J. Hopkins, F.R.A.S. Mr. Hopkins is remarkable as being one of those men who have acquired astronomical knowledge without the adventitious aid of education or opportunity and purely for its own sake. When quite a lad he wrote papers on astronomical subjects of merit such as to bring him under the notice of men like Prof. Stokes and Lord Lindsay, who showed much interest in his work. Last year he published a small book, 'Astronomy for Everyday Readers,' which, though unpretentious, obtained such success as to procure him a grant from the Royal Bounty Fund.

A case of a little astronomical interest has lately come before the Liverpool law-courts. A levy, by sheriff's order, was made on the household goods of some person, who urged that this was illegal as it was done after sunset, the director of the Liverpool Observatory being called to testify to the time of sunset on the day the objection was upheld. It seems natural to assume that for this purpose the time of *local* sunset is the legal limit, but generally in legal documents the word "time" as pertaining to the whole of Great Britain is to be understood as Greenwich Mean Time, although there is a precedent on record where it was held that the time stated for the opening of a court was to be reckoned by the local time of the place.

We have received a circular announcing that it is proposed to hold an Astronomical Congress in San Francisco in June next, in connection with the Californian Mid-winter International Exhibition. Astronomers who would be likely to attend or would be willing to contribute papers are invited to communicate with Mr. W. M. Pierson, Chairman of the Committee on Astronomical Congress, Mills Building, San Francisco.

Mr. Marth's Ephemerides of the five inner satellites of Saturn were published in the January number of the 'Monthly Notices.' The Rev. A. Freeman points out that the times of the elongations of Mimas given in the "Companion" are two hours late compared with Mr. Marth's Ephemeris. In the cases of the other satellites the two ephemerides are in fair agreement.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 214. MAY. 1894.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, April 13, 1894.

Capt. W. de W. **Abney**, C.B., F.R.S., *President*, in the Chair.

Secretaries: Prof. H. H. **Turner**, M.A., B.Sc., and
E. W. **Maunder**.

The Minutes of the previous Meeting were read and confirmed.

Mr. Maunder. 71 presents have been received since the date of the last Meeting, but none of them call for any special comment.

A vote of thanks was passed to the donors.

Prof. Turner. A very interesting letter has been received from Mr. H. C. Russell, but a number of slides that have been forwarded have not yet arrived. The letter refers to star cluster 3315, of which Mr. Russell has taken two photographs to see if there are any nebulous stars in the cluster, and he has found none, and it may therefore be assumed that there is no nebulous background in cluster 3315 at all approaching to that of the Pleiades in brilliance. Reference may again be made to the paper when the slides arrive.

Mr. E. B. Knobel then took the chair whilst *Capt. Abney* read the following paper.

The President. The short paper I have to bring before the Society is diagrammatical rather more than anything else, and therefore I propose not to read it in full, but simply to explain the diagrams as they come upon the screen. It will be in the recollection of most of the Fellows of the Society that there has been a good deal of discussion as to the method of graduating a photometer-wedge, and on two occasions I have read a note on the different methods which have been adopted. Now I have in my possession several dark wedges which I use in experiments for the extinction of light and so on, and I wish to show you a very easy way in which a wedge of any colour may be graduated. When you have a very dark wedge an ordinary candle or lamp is totally insufficient to get a light through it in order to enable you to get readings comparable with one another. In order to get a more brilliant light I had recourse to electricity, and I made the electric light its own comparison light.

[Diagrams of the apparatus being thrown on the screen, Capt. Abney explained his process of comparison, which consisted in a beam of light from a single source being divided, after passing through a slit and collimator, by means of reflection into two beams, both of which finally fell on the same area of a screen. The light from one beam, called the comparison light, was capable of being varied in intensity by means of a sector placed in its path. In the path of the other beam the wedge was placed, and the evaluation of the wedge was made by comparing the intensity of the light as it passed through different parts of the wedge with the intensity of the comparison beam varied by means of the sector.]

The image can be made as fine or as bright as is wished. The wedge can be graduated for white light and can be compared with the same light. The thickest wedge that I have cuts off 999 thousandths of the light, and you can scale to the very end. The novelty of the plan is that the same source is used for the light to be measured and for the comparison light. I and my assistants have made many graduations of the same wedges in this way, and we find after an interval of a year or two that there is very little variation in the results, and therefore I think it is likely to prove a satisfactory method for graduating the wedges used for star work.

Dr. Spitta. The subject of scaling a wedge is one of the greatest interest to me personally, as perhaps the controversy I had with the late Professor Pritchard about this matter some years ago may be within the recollection of some of the Fellows present. I may mention that whilst first using the wedge-photometer I was irresistibly led to the belief that its coefficient must be too high, and so I accordingly tested it by three distinct methods, all based on different lines. The result, right or wrong, was that with all the three I found my constant sensibly lower than that obtained by the Oxford polarizing method. Capt. Abney then attacked the subject, and very kindly tested my wedge by his photographic method; and his coefficient came out almost identical with my own, and consequently sensibly lower than the Oxford one. Through the kindness of the late Professor I then tested another wedge (although not either of the historic Oxford ones), but again the same error appeared to be present; that is to say, the Oxford evaluation was higher than mine. I may, perhaps, be permitted further to state that I ultimately traced (anyhow to my own satisfaction) the actual cause of the error in the polarizing method of scaling the wedge, proving beyond doubt—at least, so it appears to me—that such arises from the augmenting effect of certain polarized reflections from the internal surfaces of the Nicol's prism used of necessity in this process. Further, through the cleverness of Mr. Hilger—I trust he will pardon me, for I see him here present—who rapidly grasped the point, and who cut me an original and specially ingenious Nicol, I was enabled to project on the screen with my lantern, in this very room, the reflections about which I have just spoken. I really thought this would have convinced anyone; but I do not think, intimate as I was with the late Professor, I ever saw any visible sign of his immediate or even his remote conversion.

Prof. Turner. I think we all agree that the researches of Capt. Abney in the fundamental principles of photometry are of the utmost importance at the present moment. A new departure was initiated in 1887; but photographing the stars carries with it several problems on visual photometry. This subject is one on which Capt. Abney is apparently engaged, and it is of the utmost importance in every respect. On a very late occasion we found that Capt. Abney is not at all backward in telling exactly what modifications he has had to make in his previous researches, and although that is an attitude which we should expect in most scientific men, we do not generally get it so readily taken up by them. We always feel the utmost confidence in the announcements Capt. Abney makes when he feels he has something new; and I can share with Dr. Spitta the hope that he will be able to find time to apply his new method to those which have been forming the basis of the method of photographing the stars. For my own part, I should be glad if I could induce Capt. Abney to show me what might be done in the way of redetermining the graduation of the Oxford wedge, or to do it himself, which would be much better. I think the world cannot but be all the better for learning exactly what are the scale values of such measures entering into our fundamental method of stellar photometry.

Father Sidgreaves. With reference to the last photograph shown on the screen, I should like to ask Capt. Abney why he divides the beam before passing the light through the two prisms instead of passing it through one prism and then dividing the rays after that. My difficulty is this: that in the arrangement there are two slides, one to gather a particular colour for one of the cameras and the other for gathering the same colour for the other camera, and it seems to me that this is defective because it depends upon the eye whether you have the same part of the spectrum. I think an arrangement might be made to pass it through the one prism first and then divide it so that you have one colour absolutely for both cameras.

Capt. Abney. In reply to Dr. Spitta I may say one must have a doubt, particularly after the researches he has made, as to the value of the polarized light method of graduating a wedge. It always seems to me there are so many things to be taken into account when you are using polarized light that you have to be very cautious how you accept the results obtained by that means. For instance, in taking the different colours of the spectrum it is absolutely impossible to get extinction with the Nicol prism; a certain amount of light always comes through; there is always some slight defect; and therefore one is obliged to resort to a wedge or some other device by which you can get the proper amount of light. In reply to Mr. Turner, I shall be only too glad to have the opportunity of putting the Oxford wedge through my mill. It is a thing I have often wanted to do simply for the sake of what has gone before. In reply to Father Sidgreaves, the usual plan which I have adopted would meet his objection. The arrangement here shown was adopted for a practical reason, but you are only using one colour and the standard remains the same.

Dr. Spitta. That is a most interesting point just alluded to by Capt. Abney about the impossibility of obtaining *absolute* darkness when two Nicols are crossed, and it is perfectly true, although I do not recollect having heard it mentioned by anyone save himself —that is, except in very general terms. I am prepared to show that this is due entirely to these very reflections about which a few minutes ago I was permitted to speak; and, moreover, I am still further prepared to show that such reflections are polarized—strange as it may at first sight seem—in planes different to those of the ordinary and extraordinary rays with which we are all familiar: in other words, the reflections are not polarized in the same plane as the rays giving rise to such reflections, which is curious, but is nevertheless the fact. After a little consideration, however, anyone will follow me that it is absolutely essential that these planes should be slightly turned, for if it were not so, the primary crossing of the Nicols in the first place would of itself have annihilated the reflections, and so darkness *would* have really resulted. As a still further proof I may add that if after crossing the first two Nicols you were to add two more, crossed at the necessary angle of rotation with respect to the first two, then absolute darkness *is* really effected. This is not a theoretical fancy, but capable of being actually put to experimental proof.

Prof. Turner then exhibited and explained instruments he had designed to facilitate the computation of star-corrections. He showed that a star-correction was the sum of three functions of the form $p \sin(P+a) \sin \delta$, and his apparatus gave means of calculating this function rapidly for different values of the variables by means of movable scales.

Mr. Stone. Have you calculated any corrections to see how they come out?

Prof. Turner. I did 40 one afternoon, and the instrument gave fair agreement with computation, but it was with a very rough instrument.

Dr. Downing. This is a very important subject which Prof.

Turner has brought before us, and it is useful to practical astronomers, especially to those engaged in observatories. It is not of quite so much consequence to the work of such an office as that over which I have the honour to preside, where we calculate the places of a limited number of stars for definite intervals. In a case like that I think an extended Crelle's multiplication-table would be rather more useful, but in an observatory any machine of the kind Prof. Turner has indicated for computing star-corrections is a most valuable one. It is impossible to criticise the thing in detail, but from what Prof. Turner has said it would appear that he has hit upon a device which ought to be most useful in this respect, and I think the thanks of practical astronomers are due to him for the trouble he has bestowed upon the subject, and I hope it will be extensively used and its value proved by that means.

Mr. Stone. The idea is a comparatively simple one. It might lead to a great saving of time, but at present I think a great deal depends upon the person who makes use of it.

Sir Robert Ball. Everyone who has had experience of such a machine knows that though it may not be capable of very great accuracy, it prevents making great mistakes, and is an excellent means of control on computations. I do not know whether Prof. Turner has ever used Colmar's Arithmometer. I have found it a most valuable ready-reckoner for all kinds of computations, and I find I can work out computations by that better than I can in any other method. I have used the Arithmometer extensively for computing equations, and results come from it with the greatest possible ease. I particularly admire the way Prof. Turner has devised for varying the factor by just shifting the base of his T-square.

Prof. Alex. Herschel. In multiplying the cosines and sines of angles the Arithmometer is at a disadvantage; but when it is merely a multiplying of terms, Arithmometers are very useful. I may mention that the use of the Brunswick Arithmometer has been shown to be far superior to Colmar's. The rapidity with which you can multiply seven figures by seven figures is wonderful. It is very convenient to get an instrument of this sort for Observatory practice.

Dr. Downing. As to the Arithmometer which has been referred to, for the last few years we have made extensive use of Colmar's Arithmometer, and have found it very useful; but the objection to it is the noise it makes in rotating the handle. If there is more than one man in a room, those not using the instrument object to it because of the noise.

Prof. Alex. Herschel. The Brunswick makes some noise, but not so much as a sewing-machine.

Prof. Turner. I am much obliged to Sir Robert Ball for his remarks, and especially for his use of the word "control"; I mean to say, I do not intend in the first instance to use this as a fundamental method of computing star-corrections. I think at Greenwich it might be used for control instead of doing the work twice over independently. It might avoid some errors which were found to creep in, in what we thought was a complete method of avoiding mistakes. Dr. Downing refers to extended tables for multiplying. I do not know whether that is within the range of practical politics. Has he considered how many volumes it would take to do what he proposes?

The President. I have been struck with the very ingenious device which has been brought forward, and I quite agree with Sir Robert Ball that the more ways we have for controlling the better it is.

Dr. Isaac Roberts then exhibited some photographs of the Cluster M 46, and of the Nebula ♅ IV. 39 Argûs, taken with the 20-inch reflector on 1894, Feb. 24, with an exposure of 90 minutes. The Cluster is numbered 2437 in the New General Catalogue and 1564 in the General Catalogue, and the Nebula is 2438 in the N.G.C. and 1565 in the G.C. The photograph, Mr. Roberts said, left no doubt that it is an annular nebula. The next photograph shown was one of the Nebula ♅ I. 156 Persei, taken with the 20-inch reflector on 1893, Dec. 29, with an exposure of 3 hours. The Nebula is 1023 in the N. G. C. and 575 in the Gen. Catalogue. The photograph showed the nebula with a distinct stellar nucleus, and extensions of faint nebulosity in the *preceding* and *following* directions. Dr. Roberts also showed a photograph of the new spiral nebula in Perseus.

Mr. Knobel (who had taken the Chair, Capt. Abney having left). Dr. Roberts continually surprises us with the photographs he continues to show us. I think the most remarkable thing about them is the confirmation of the remarkable drawings of Lord Rosse. There is hardly anyone in this room but who knows that we looked with the utmost scepticism upon the spiral nebula of Lord Rosse, but the accuracy of the drawings has been proved over and over again by the photographs of Dr. Roberts. . . . The planetary nebula is extremely interesting, and confirms the drawing of Lord Rosse, which shows it to be an annular nebula with a good many rays around it. It was very clear to perceive how Lord Rosse's drawings could have been constructed out of the photographs Dr. Roberts has shown us. The object is very clearly visible with a small telescope. I remember seeing it 25 years ago with a very small telescope. The object he has last shown of 156 of Herschel's First Class is a fairly bright object, and my recollection of it is as described by Prof. Smyth and Sir John Herschel. I remember seeing it elongated, but I cannot remember whether it was in the direction described.

Dr. Spitta. I should like to ask Dr. Roberts whether the photographs were taken with isochromatic plates or with ordinary plates; because one can conceive of the isochromatic plate being more sensitive in a certain part of the spectrum than in another.

Dr. Roberts. I found the isochromatic plates supplied by

Edwards very much too slow for my work. I cannot get from them so much as I can from the Ilford form. I found the isochromatic plates did not give anything approaching the good result I got from other plates, so I did not continue them.

Mr. Newall, in exhibiting some photographs taken with the Cambridge 25-inch visual refractor, said:—These photographs are a digression from my regular work of spectroscopy. They were taken mainly for the purpose of testing the performance of the object-glass in photographic work, and the results may prove to be of interest to the Society. This first plate shows, in parallel lines, photographs of the spectrum formed by placing a prism before the object-glass, and with the photographic plate placed at different focus readings. The photographed spectra are trumpet-shaped, the narrowest part of any spectrum being due to the light that is accurately focussed on the plate. It will be noticed that the position of the narrowest part of the lines moves towards the violet end of the spectrum as the plate is moved from the object-glass, and we have thus a convenient method of forming the colour-curve of the telescope.

It is interesting to note that the object-glass was originally achromatized for visual work; this photographic method gives for focus of the F ray the same reading as is used for visual work. Thus the adjustment of the objective prism in front of the object-glass has altered the focal length by less than ½ an inch, a fact which shows how excellent the surfaces of the prism must be. As the prism was of smaller dimensions (10½ inches circular aperture) than the object-glass, and therefore the centre of the glass only was used, it is necessary to determine the difference, if any, between the effect of using the centre of the object-glass or the external annulus only.

This second plate shows photographs of a star at different focus-readings near the visual focus—firstly with a ·6-inch aperture at the centre of the glass, and secondly with an annular aperture half an inch wide at the outer boundary of the object-glass. The appearance of the images under the two conditions convinces me that the longitudinal spherical aberration is less than $\frac{3}{16}$ inch, and that one may take the colour-curve determined for the centre of the glass as representative of the whole.

(Photographs of stars were then shown: they were taken under varied conditions of exposure and focus-reading on plates of different kinds.)

The nature of the colour correction of a large object-glass gives rise to considerable difficulty in spectroscopic work, and to obviate some of these difficulties I have had an uncorrected lens made, which I set between the object-glass and the focal plane of the telescope, about 5 feet from that plane, and have got very promising results with it. I have enlarged the "corrected" image of Jupiter obtained with this lens by the well-known method of attaching a camera to the telescope. The slide which I show gives an idea of the result obtained. The original plate shows a good deal of detail, but leaves me desiring much more. Jupiter is undoubtedly a difficult object; the detail is so fine. That the correcting-lens and camera are not wholly at fault is proved by the enlargement of lunar craters obtained with them in the process of focussing. I exhibit slides of Copernicus and Petavius.

Mr. Knobel said that there were many points in the paper that Members no doubt would have been glad to discuss had time allowed.

The Meeting adjourned at 10.15 P.M.

The following papers were announced and partly read:—

A. A. Rambaut. "Occultation of α Virginis observed at Dunsink, 1894, March 22."

Isaac Roberts. "Photographs of the Cluster M 46, and of the Nebula ♅ IV. 39 Argûs."

Isaac Roberts. "Photograph of the Nebula ♅. I. 156 Persei."

Isaac Roberts. "Photograph of a new Spiral Nebula in Perseus."

H. C. Russell. "The Star Cluster 3315."

David Gill. "Remarks on the best Method of Determining the Positions of the Planets by Observation."

H. Dennis Taylor. "An Experiment with a 12½-inch Refractor, whereby the Light lost through the Secondary Spectrum is separated out, and rendered approximately measurable."

H. F. Newall. "Note on some Photographs taken with a Visual Telescope."

Capt. W. de W. Abney. "On a Method of Graduating a Wedge."

Royal Observatory, Greenwich. "Observations of Denning's Comet (a 1894)."

W. E. Plummer. "Observations of Denning's Comet (a 1894)."

A. Marth. "Ephemeris for Physical Observations of Mars, 1894."

The following gentlemen were elected Fellows of the Society:—

F. W. Dyson, M.A., Fellow of Trin. Coll., Camb., Royal Observatory, Greenwich, S.E.; *Lyndon Bolton*, B.A. Cantab., Patent Office, Southampton Buildings, W.C.; *G. P. Jenkins*, National Provincial Bank, Llangefin, Anglesea, N. Wales; *W. Redfern Kelly*, Mem.Inst.C.E., Dalriada, Malone Park, Belfast.

The following Candidates were proposed for election as Fellows of the Society:—

Rev. John Thomas W. Claridge, M.A., Tamworth, Staffordshire (proposed by Rev. T. Jones); *John Benjamin Stone*, K.B., The Grange, Erdington, near Birmingham (proposed by W. Shackleton); *David Goudie Simpson*, 199 Camberwell Grove, Denmark Hall, S.E. (proposed by Hon. Mr. Justice Bruce); *Rev. Ernest Harrison Smith*, M.A., R.N., Chaplain and Naval Instructor, H.M.S. 'Tourmaline,' N. American and W. Indian Station (proposed by Bertram Bennett).

BRITISH ASTRONOMICAL ASSOCIATION.

The fifth ordinary Meeting of the current Session of this Association was held on Wednesday evening, March 28, at University College, Gower Street, W.C., the President, Dr. A. M. W. Downing, M.A., D.Sc., in the Chair.

Eleven new Members were elected, and the names of six candidates for membership were suspended. The President announced that subscriptions to the Library Fund to the amount of £11 *2s. 6d.* had been received, and he trusted that when the matter became more widely known there would be a greater response.

Mr. E. Walter Maunder, F.R.A.S., presented the report of the Mars Section. He stated that notwithstanding the unfavourable position of the planet as seen from England, and the unfavourable observing weather during the autumn of 1892, he had received 86 drawings, of which 80 were available for use. He had been much pleased at the amount of detail that had been recorded by English observers, some of whom had only very small telescopes at their disposal. A number of lantern slides prepared from drawings by the Members of the Section, together with others by Prof. Keeler and the Lick observers, were then shown and explained by Mr. Maunder. These were followed by a set of eight lantern slides of Jupiter, from drawings published by Prof. Keeler in the the 'Publications of the Astronomical Society of the Pacific.' *Mr. Chambers* criticized the very strongly-defined lines and markings which so many observers were in the habit of depicting on Mars, and, indeed, on Jupiter, Saturn, and even Venus. He thought Mr. Green's drawings of Mars were the only satisfactory and artistic ones he had ever seen.

Mr. Holmes advised a judicious use of india-rubber on the drawings. Referring to Prof. Keeler's drawings of Jupiter he thought the belts were not accurately placed, and that a draughtsman who could commit so great an error was not to be trusted in fine detail.

Miss Everett read a note on "The Large Sun-spot of February 1894," by Mr. E. M. Antoniadi. A peculiar fact was rendered evident by the inspection of the writer's drawings. The umbra was shown to have rotated by an arc of at least 20° in the direction of the hands of a watch in the short space of only five days—from Feb. 17 to 22.

Mr. J. Evershed, Junr., then read the Report of the Solar Spectroscopic Section, which stated that, during 1893, 244 complete observations of the chromosphere had been obtained by Members. From this material the prominence activity of the Sun had been worked out by the method adopted in former years. The general result, including 1892, was that the average activity had remained nearly constant, there having been no increase, as might have been expected, as the sun-spot maximum was approached. When, however, the two hemispheres of the Sun were considered separately, great variations were found in 1893. The diagrams exhibited showed clearly the general independence between the phenomena of prominences and spots, the former being mostly developed quite outside the spot-belts.

Mr. E. Walter Maunder next read a note on "How to make a Spider-line Reticule."

Mr. Chambers wondered how many in the room were clever enough to construct a reticule in the way Mr. Maunder had described. He had one made of fine brass wire by Sir Howard Grubb, which he found answered admirably. *Mr. A. Hilger* contended that a spider-wire reticule was far superior to any other kind, and would last 15 or 20 years; and in reply to Mr. Chambers said it was easier to make than one of brass wire.

A paper on "The Formation of a Venus Section," by Mr. F. J. Wardale, F.R.A.S., was read by *Miss Everett*, and the Meeting then adjourned at 7 P.M.

ROYAL METEOROLOGICAL SOCIETY.

At the Meeting of this Society, held on Wednesday evening, April 18th, at the Institution of Civil Engineers, Great George Street, Westminster, Mr. Richard Inwards, F.R.A.S., the President, delivered an Address on some phenomena of the upper air. He said that there are three principal ways in which the higher atmosphere may be studied: 1st, by living in it on some of the great mountain-chains which pierce many miles into the air in various parts of the globe; 2nd, by ascending into it by means of balloons; and 3rd, by the study of the upper currents as shown to our sight by the movements of the clouds. After describing the effects of rarefied air on animal life and natural phenomena, Mr. Inwards proceeded to give an account of various balloon ascents which had been undertaken with the object of making meteorological observations. In 1850, Messrs. Barral and Bixio, when they had ascended to 20,000 feet, found the temperature had sunk to 15° Fahr., but this was in a cloud, and on emerging from this 3000 feet higher, the temperature fell as low as *minus* 38°, or 70° below freezing-point. In 1862 Mr. Glaisher and Mr. Coxwell made their famous ascent, when they reached an altitude of about seven miles from the Earth. A short time ago a balloon, without an aeronaut, but having a set of self-recording instruments attached, was sent up in France, and from the records obtained it is shown that a height of about 10 miles was attained, and that the temperature fell to *minus* 104° Fahr. Clouds are simply a form of water made visible by the cooling of the air, which previously held the water in the form of invisible vapour. Every cloud may be regarded as the top of an invisible warm column or current thrusting its way into a colder body of air. After referring to the various classifications and nomenclatures of clouds, of which that proposed by Luke Howard in 1803 is still in general use, Mr. Inwards said that whatever system of naming and classifying clouds be adopted, it should depend on the heights of the various clouds in the air, and he gave a few rough rules by which the comparative altitudes of the clouds may be judged when there is no time or opportunity to make exact measurements. Among the indications by which a cloud's height in the air may be gathered are its form and outline, its shade or shadow, its apparent size and movement, its perspective effect, and the length of time it remains directly illuminated after sunset. By the last method some clouds have been estimated to have been at least 10 miles above the surface of the Earth. The cloud-velocities at high altitudes have been carefully noted at the Blue Hill Observatory, Mass., U.S., and show, practically, that at about 5 miles' height the movement is three times as fast in summer and six times in winter, as compared with the currents on the Earth's surface.

After showing a number of lantern-slides illustrating the various types and forms of clouds, the aurora borealis, rainbows, &c., Mr. Inwards concluded his Address by urging the desirability of establishing a good Cloud Observatory somewhere in the British Isles.

At the close of the Meeting the Fellows and their friends inspected the Exhibition of Instruments, Photographs, and Drawings relating to the representation and measurement of Clouds, which had been arranged in the rooms of the Institution. A lantern display of slides showing cloud-effects and other meteorological phenomena was also given.

The Diameter of the Moon [*].

THE knowledge of the exact position of the Moon deduced from observation has as great importance from a practical point of view as from considerations of celestial mechanics. The theory of the motion of our satellite offers peculiar difficulties for analysis. In the first place, the action of the Sun on the motion of the Moon round the Earth is so considerable that it cannot be neglected without very great errors even in a first approximation. Secondly, the small distance of our satellite makes prominent any small deviations in its real position.

It is therefore important that the determination of the Moon's coordinates, especially its R.A., be determined as exactly as possible, and free from systematic errors. But the position of the Moon's centre cannot be obtained directly; this can only be obtained by measurements of the positions of its limbs. Transits of both limbs are only possible at full Moon, and at this phase it is analogous to finding the position of the Sun. In the latter case the problem is sufficiently complicated from the fact that the determination of the transit of a limb is mixed up with the personal equation of the observer *. If this personal equation were the same for both limbs it could be treated as in the case of a star; but such is not the case, the observer generally noting the passage of the first limb too soon, and the second limb too late. From the whole set of observations made in 1891 and 1892 at Paris, with the aid of a special apparatus, we have been able to conclude that the first limb is observed $0^s.14$ too soon, and the second limb $0^s.03$ too late. Other observers have found similar discordances. MM. Callandreau, Hamy, and Viennet, of the Paris Observatory, made observations with disks about the size of Saturn's apparent diameter, and the results are as follows :—

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[*] Translated from 'Ciel et Terre,' 1894, April 2.

	1st limb.	2nd limb.
Callandreau	$0^s.05$ early	$0^s.06$ late
Hamy	0 .06 ,,	0 .02 ,,
Viennet	0 .17 ,,	0 .22 early

It has been found that the size of the disk has very little effect on the results.

It would seem, then, that the diameter obtained from transits might be too large †, for

Callandreau	$0^s.11$
Hamy	0 .08
Stroobant..................	0 .17
Viennet	0 .05

and points to the necessity of determining these quantities for each observer.

The question is much more delicate when only one limb can be observed, as is ordinarily the case for the Moon. The true position is then dependent entirely on the assumed value of the semi-diameter ‡. The results obtained for the magnitude of the Moon's diameter diverge one from the other, more or less, according to the means at the disposal of the observer and to the method employed. Passing rapidly in review the principal determinations, we see that all the older values are too large; thus

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* [In the case of the Sun this question of personality has a direct bearing on the correction to the Equinox, and is at present being investigated at the Royal Observatory, Greenwich.—Eds.]

† [That these observers should obtain a diameter too large is fortuitous. Mr. Dunkin found, in discussing some Greenwich observations of the Sun, that the tendency of the then observers was quite the other way.—Eds.]

‡ [At the Royal Observatory, Greenwich, a correction to the semi-diameter is applied in the reduction of the altazimuth observations, deduced from observations of the Full Moon. For almost all the observers the tabular diameter is too small.—Eds.]

		′	″
Ptolemy (A.D. 130)	assigns to it	33	20
Albategnius (A.D. 880)	,,	32	25
The Hindoos (about 1100)	,,	32	
Copernicus	,,	31	36
Tycho Brahé	,,	30	50
Kepler	,,	31	20
Huygens	,,	31	25
Lahire	,,	31	30
T. Cassini	,,	31	34
Le Monnier	,,	31	35
T. Mayer	,,	31	28·5

There are six methods employed by modern astronomers:—

(1) Micrometer measures;
(2) Meridian passages;
(3) Heliometer measures;
(4) Photography;
(5) Occultations of stars by the Moon;
(6) Eclipses.

The first method consists in placing the two micrometer wires tangential to the limbs at the time of Full Moon. Various causes, physiological and physical (irradiation, diffraction, &c.), tend to augment the apparent diameter; thus this method, although the most simple, is far from the best. In the meridian-passage method the instant at which each limb transits the wires is noted, the difference in time being then converted into arc. We have already seen that this method is subject to systematic errors; our determinations, for example, would give a diameter too large by $0^{s}\cdot17 \times 15$ *, or $2''\cdot25$.

To effect a measure with the heliometer it is necessary to place in contact, tangentially, the two images (produced by the two movable halves of the objective) of the disk. This method, applied in the first instance to the Sun, is one of those which yield the best results.

The apparent diameter of our satellite could also be determined by photographing on the same plate the lunar disk, and a reticule on which the distances from thread to thread had been previously determined by stellar observations. But when the exposure is not very short it can be imagined that the image formed on the photographic plate is somewhat dilated, so that the diameter sought for would be enlarged. If it is wished to determine this element by means of occultations or eclipses, the greatest consideration is the knowledge of the motion of the Moon. It is very evident, in fact, that the instant of disappearance or reappearance of a star, or the moment of contact with the limb of the Sun in eclipses, depends not only on the position of our satellite in the sky, but also on its apparent diameter.

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* [This is, of course, on the supposition that the Moon is at the time on the Equator. In other cases it would be 15 . sin N.P.D.—Eds.]

M. Oudemanns[*] has explained why it is necessary to discard the determinations deduced from eclipses of the Sun, which give a value too small.

The following are the principal results obtained, since the commencement of the present century, by various methods :—

	′	″
[†]Airy, from Greenwich Observations of zenith: distances from 1750 to 1830	31	19·82
meridian observations 1857 to 1860	31	9·36
occultations observed at Greenwich	31	5
Wichmann, heliometer measures in 1849	31	6·62
[‡]Pritchard, photography in 1879	31	8·34
Ferrer, eclipses and occultations, 1815	31	3·38
" " " 1831	31	4·68
Wisniewski, occultations of Aldebaran, 1838..	31	4·8
Carlini, eclipse of the Sun 1842, July 8	31	2·6
Oudemanns, occultations and heliometer-measures, 1859	31	4·54
Oudemanns, eclipses of the Sun	31	2·4
Küstner, occultations of Pleiades, 1880	31	5·702
M. L. Struve, occultations during Total Lunar Eclipse, 1884, Oct. 4..................	31	5·3

[This list does not include the result of the eclipse in 1888. Dr. Ludwig Struve has discussed the two sets of observations (1884 and 1888) and his remarks are very interesting. He arranges the stars in four groups according to their magnitude, and finds the corrections to the various values of R.A., Dec., diameter, and parallax proceed in progressive series according to the magnitude, suggesting a systematic error depending on the brightness of the star. He further remarks that the illumination of the Moon, which was fairly bright, even at mid-totality, influenced the observation of the fainter stars. His definitive result is

Semi-diameter $= 15' \; 32''{\cdot}645 \pm 0''{\cdot}004$. Eds.]

It is easily seen that the method of occultations gives the most accordant results, and it is the only one in which the apparent diameter of the Moon is not augmented by physical or physiological causes.

It would appear, taking the latter numbers as a basis, that the apparent diameter of the Moon is comprised between the limits

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[*] Vergelijking der Waarde in de "Tables de la Lune" van Hansen aan der straal der Maan toegekend, 1859.

[†] [It is to be understood that this is not a value of the diameter derived from a rigorous discussion. Each observed semi-diameter was compared with the tabular and a correction necessary to make the tabular semi-diameter agree with observation found. "As the absolute diameter to which these corrections are applicable could not be found without considerable trouble, it was considered that no sensible inaccuracy could arise by using the same mean provisional semi-diameter as before: hence (Introduction to Greenwich Observations, 1841, p. xlix) $+2''{\cdot}55 - 0''{\cdot}36 + 937''{\cdot}2 = 939''{\cdot}91$ is considered to be the true vertical semidiameter agreeing with observation."—Eds.]

[‡] [This is a complete discussion of the question, and compares the results obtained by the photographic method and those obtained by Wichmann, Memoirs R.A.S. 1879.—Eds.]

$31' 5''$ and $31' 6''$. But this approximation is not sufficient; this element ought to be determined to $0''\cdot1$ nearly; the Right Ascension of the Moon could then be obtained with an error which, in general, would not exceed $0^{s}\cdot01$.

The application of photography to the determination of the exact instant of disappearance or of reappearance of a star would permit, without doubt, of arriving at great precision, especially when these phenomena occur at the dark limb of the Moon, or during eclipses, when a number of small stars can be observed. Let one imagine a sensitive plate to be moving uniformly in the focal plane of an objective; the star will trace out a continuous line which will be suddenly interrupted at the moment of disappearance, or will show the instant of reappearance. Suppose, next, that a screen is periodically interposed between the plate and the objective during a very minute space of time, it will produce breaks in the continuous line from which the instant of disappearance or re-appearance could be fixed. About every 19 years the Moon passes over the Pleiades in conditions more or less advantageous for observation; this phenomenon will occur next year. Might not the occasion be profitably used in securing a number of photographs at various Observatories? If these are sufficiently separated from one another it would be possible to deduce a new value of the parallax of the Moon.

P. STROOBANT.

Melting of the Polar Caps of Mars.

IN 'Astronomy and Astro-Physics' for 1892, p. 665, is given an account of a series of conspicuous changes that were observed upon the surface of Mars at the time of the melting of its southern snow-cap. These changes were so marked that many of them could be readily observed this year with any moderately large telescope, although the position of the planet at this time will be much more favourable than was the case in 1892. In that year upon July 12 a central branch made its appearance in the fork of the Y mark. This branch will lie just south of Noachis upon Schiaparelli's map. It was soon seen that this central branch formed a portion of a dark line connecting the great split in the southern snow-cap with the Northern Sea. This sea lies in the northern portion of the Syrtis Major, and is much darker than any of the surrounding regions. Immediately upon the formation of this connecting-link, a series of striking changes occurred in the shape and colour of the regions surrounding the Northern Sea. These changes are fully described in the article referred to above, and no further description of them is necessary in this connection. The apparent alterations from night to night were very marked, and the whole series of changes was completed inside of two weeks.

The point to which I wish to call the attention of astronomers at the present time is that upon May 30, 1894, Mars will reach the same portion of its orbit with regard to the Sun that it did upon July 12, 1892. It is therefore presumable that a similar series of changes will occur about that date. As Mars will be a morning star at this period, rising about midnight, and will at the same time be rather remote, it is not likely that there will be many observers watching it; and for this reason every available observation will be of much greater value than would otherwise be the case. The centre of the Northern Sea, longitude 290°, is central May 30^{d} $22^{h}\cdot 5$ G. M. T.: therefore, if the expected changes occur exactly on time this year, the European astronomers will see only the end of them. On the other hand, there is no reason for expecting any meteorological phenomenon to occur on precisely the same date upon two successive years, and should the thaw begin one or two weeks earlier or later this year upon Mars than it did last, the best opportunities for observation will undoubtedly be found in Europe.

William H. Pickering.

Cambridge, Mass., U.S.A.,
1894, March 22.

Selenographical Notes.

The Region West of Plato, Plato *i*.—About midway between the mountain-mass marked ψ in Neison's Map VI. and the south-western flank of Plato, Schmidt shows a crater, *i*, three or four miles in diameter, with a companion rather less than half the size adjoining it on the east. Neison draws the pair smaller and some distance apart, and Mädler of the same dimensions but touching each other. While watching the progress of sunrise on the region on April 13, under very excellent atmospherical conditions, I noticed that this object (which at 9^{h} was bounded on the south by that part of the prominent shadow due to the eastern side of the mountain-mass ψ) bore no resemblance whatever to an ordinary crater, but was represented by a large circular bladder-like protuberance at least 12 miles across, with a very shallow round depression, perhaps 3 miles diameter on its summit, the interior of which was only slightly, if at all, darker in tone than the surface of the neighbouring Mare Imbrium. No indications of the smaller companion crater were visible, but this possibly was hidden by the shadow of the mountain, though the spire of shadow was very narrow on its site. The sky clouded over before it had retreated sufficiently for observing the position. As sunrise advanced, and till 9^{h} 30^{m}, no apparent change was observable in the appearance of the protuberance, which reminded one of that seen under a low Sun on the Mare Tranquilitatis east of Arago, albeit this has no depression on its summit. Though during the past 35 years I have observed and drawn the details associated with Plato very frequently under various conditions of illumination, and have on many occasions seen this crater *i* and its companion much as it is represented by Mädler, viz. as two craters with rims, nearly equal in size, it has never been noted as it appeared on April 13. Experience has taught me to hesitate before suggesting the probability of visible change in lunar details. In this part of the Moon's surface especially, a very slight difference in the angle of illumination often brings about striking alterations in the aspect of familiar features; but, making every allowance for this, it is difficult to understand why an object which has been noted over and over again as a crater with a distinct rim and a black interior should, under nearly the same conditions, appear as a large protuberance of much greater area with a shallow depression on the top filled with only a geeyish shade, very different from the ordinary shadow of a crater-wall seen under a low Sun. At any rate the object is well worth watching, and I trust some observers will take an early opportunity of observing it during the next two or three lunations. I may add that at $5^h\ 30^m$ to $6^h\ 30^m$, on February 1, 1887, with a power of 340 on my 8½-in. Calver reflector, a very good view was obtained of the object, which then appeared to consist of twin craters nearly equal in size, filled with black shadow. On this occasion I noted that for some distance on the south-west side of the pair the surface of the Mare was of intense whiteness, similar in character to the glistening halo associated with light-surrounded craters. The position of the protuberance was carefully fixed by alignments with well-known objects, so that there can be no doubt as to its identity with the craters marked *i* on the Maps.

Though Plato has perhaps been more sedulously scrutinized by observers than any other lunar formation, observations have been almost exclusively confined to the spots and markings on the floor, or, at any rate, have not, as a rule, extended much beyond the limits of the circumvallation. Anyone, with adequate optical means, who will take the trouble to devote a few hours to the examination of the region lying between it and the great Alpine valley will discover how very inadequately, not to say inaccurately, it is represented in some existing maps. Schmidt's representation is very much the best, but many prominent features appear very clearly to be misplaced and out of scale. The region beyond the north-west wall and the valleys and other details in the vicinity of the eastern border are only indifferently shown, while insignificant objects are often exhibited with undue prominence.

THOS. GWYN ELGER.

Beaumont House, Shakespeare Road,
Bedford, 1894, April 19.

On the Scaling of a Wedge.

At the last Meeting of the Royal Astronomical Society, Captain Abney explained a new process for visually evaluating a glass wedge such as is used in a Pritchard's photometer, in contradistinction to his previous method, which was by photography.

The discussion that followed led to the reconsideration of the vexed question between the late Professor Pritchard and myself as to the suitability of the method he employed to obtain the coefficient of absorption in the Oxford wedge, and additional interest was infused into the subject by Prof. Turner offering the Oxford wedge to Capt. Abney to scale by his new method. The fact that the coefficient of the Clapham wedge obtained by Capt. Abney with his photographic arrangement agreed so closely with those I obtained by three other methods based on distinctly different lines, and yet that they one and all were so sensibly lower than that found by Prof. Pritchard's method, has always been difficult to understand unless the explanation I gave at the time be accepted.

Inasmuch as the subject has remained in obscurity for the past few years I thought it might interest some readers of 'The Observatory' if I briefly related the experiments undertaken up to the present, so as they may the more fully recognize the importance of the surroundings at the moment.

My first experience with the wedge-photometer was about 1884 or 1885, in connection with a paper read before the Society in Nov. 1887 *, in which attention was called to the fact that whilst comparing a point of light with an object of sensible area like Jupiter, a certain loss of light was found to exist. At the instigation of Prof. Pritchard I undertook a protracted research to ascertain where the error arose, and the results of this investigation have been given under three heads: (1) the method of obtaining the coefficient of absorption of the wedge †; (2) the objection of employing the single wedge-photometer and the remedy, viz. "a new form of compound wedge-photometer" ‡; and (3) experiments which show a peculiar idiosyncrasy in the photoperceptive faculty of the eye when viewing different-sized areas §. For details reference must be made to the original papers themselves; but it may be briefly stated that to test the coefficient of the wedge a machine was made to enable me to add, successively and at will, equal increments of light reflected by eight mirrors from one gas-lamp, such increments having been proved equal before commencing the observations. It was found that with a known ratio of 1 to 8 the photometer when employing the Oxford coefficient gave a ratio too high, in fact, 1 to 16·30. The coefficient I found by these mirror-experiments was ·596 mag. for every half-inch against ·71 by Prof. Pritchard. I then tried the Oxford method myself, and with the Professor's polarizing apparatus I obtained sensibly the value as he had arrived at, viz. ·71.

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* The appearances presented by the Satellites of Jupiter during transit.

† 'Monthly Notices,' March 1890.

‡ 'Proceedings Royal Society,' Vol. 47.

§ 'Monthly Notices,' Vol. li. no. 1.

A new method was then tried, viz. that of controlling the intensity of a point of light by means of an Abney's rotating disc-photometer. The results of this arrangement came out almost identical with that obtained by the mirror-method all through the series, and gave an absolutely identical ratio in the case of 1 to 8, another proof that the coefficient obtained by the Oxford method was too high.

As no solution to the difficulty was yet forthcoming, it occurred to me that perhaps suspicion might be attached to the sine law of Malus, which underlies the polarizing arrangement of Prof. Pritchard, or, rather, that admitting the theoretical accuracy of the law itself, it did not seem impossible that the practical application of it might be attended with certain unsuspected difficulties, and that hence a systematic error might be vitiating the results arrived at by its use. The discussion of the numerous experiments formed the subject of a communication to the Royal Society (through the kindness of Capt. Abney), the paper being read in June 1889. So much as relates distinctly to the wedge-photometer is contained in the paper read before the Royal Astronomical Society in March 1890 before referred to *, and the results went to prove that, owing to polarized reflections from the inner surfaces of a Nicol's prism (which had hitherto escaped attention), the ratios obtained were *always greater* than they should be, which explained why the coefficient of the wedge obtained by this method was always higher than that obtained by other means. It was ultimately found that a diaphragm would cut off these reflections, and that if it were small enough, and provided several additional precautions were also attended to, the ratios then obtained under these altered conditions were sensibly equal to those obtained by my other methods, and agreed with those known to exist. At this juncture Capt. Abney scaled the wedge by his photographic method, and without making a small allowance which he considered might be due, because he used electric light and I employed gas, his results were almost identical with those I had obtained. Tabulated they are all as follows (for each half-inch of the wedge):—

	Mag.
By reflecting mirrors	·596
By controlling a point of light by Abney photometer	·588
By the polarizing method but *with* diaphragm	·580
By Capt. Abney's photographic method	·605
By polarizing method of Prof. Pritchard but *no* diaphragm	·71

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* A special prism was cut, through the ingenuity of Mr. Hilger, to show these polarized reflections, and they were exhibited at the R. A. S. in March 1890. For a detailed description of the prism, &c., see 'The Observatory,' No. 162. Also the 'Sidereal Messenger,' No. 86.

It will thus be seen that with all four distinctly different methods the wedge-constant was lower than that obtained by the Oxford method. Prof. Pritchard did not seem inclined to pursue the matter any further, and in his reply * pointed out that his star measures all agreed with those obtained by Pickering, Zöllner, and Argelander; but he apparently quite forgot that the photometers used by the first two were polarizing ones, and that it would not be unreasonable to presume that they would be affected very possibly by the same error. And too, with respect to Argelander, his star-magnitudes have never been regarded as measures of precision; for indeed he often classifies his stars within half a magnitude. Lastly, Prof. Pritchard said that the use of a diaphragm made no difference with his observations, but rather tended to introduce a further set of errors; but to that I must take exception, for the efficiency of a diaphragm can never be proved by looking *through* a prism, because the eye cannot detect whether the polarized reflections are present or eliminated, and it is only by casting the two images of lights to be compared on to a screen that I was enabled to prove the use of a diaphragm, a fact, indeed, I did not discover until after three months' experimenting. Let this be as it may, I cannot think the fact that I obtained normal ratios with the use of a diaphragm, and abnormal ones without its use, can ever be over-rated. Perhaps I may be permitted to add that the diffused light complained of by Capt. Abney at the last meeting, which seems to prevent absolute darkness when two Nicols are crossed, is entirely due to these polarized reflections—which I could explain, but I feel I should be trespassing too much on the kindness of the Editors.

Ivy House, Clapham Common,
1894, April.

EDMUND J. SPITTA.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Comet of 1746.

GENTLEMEN,—

As the elements of the orbit recently discovered by Mr. Denning have considerable resemblance to those computed by Dr. Hind for the comet of 1746, a few words respecting the latter may now be of interest to some of your readers. Our whole knowledge of the path of the comet in question is derived from the observations of Eberhard Christian Kindermann, Astronomer to the King of Poland and Elector of Saxony, who discovered it at Dresden on the 2nd of February in the head of Medusa, and appears to have followed it until the 27th of the same month, when it disappeared in the ecliptic, between the constellations Virgo and

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* 'Monthly Notices,' June 1890.

Libra. Struyck informs us ('Vervolg van de Beschryving der Comeeten of Staartsterren,' p. 91) that Kindermann wrote an account of his observations in a tractate, entitled 'Astronomische Beschreibung und Nachricht von den Cometen 1746,' which was published at Dresden in the same year.

This little work (of only 14 pages) is rare, but a copy of it was presented not long since by the Earl of Crawford and Balcarres to the Royal Astronomical Society, and there is also a copy in the library of the University of Edinburgh. It appears to have been written towards the end of February, whilst the comet was still under observation, so that for an account of its course after that time we are indebted to a letter from Kindermann to Struyck, dated Feb. 20, 1748; and as Pingré gives only the portion of the observations subsequent to Feb. 20, 1746 (omitting those after Feb. 2 until the latter date, when the comet was in Pegasus), I here quote the whole from the above-named work of Struyck.

Seen at first in the head of Medusa on the 2nd of February, the comet is stated to have passed from near Perseus to the right leg and breast of Camelopardus and then across the tail of Draco. No dates are given for these places, but on the 20th of February we are told that the comet was in the right leg of Pegasus; on the 21st under Lyra; on the 22nd in the head of Hercules; on the 23rd in the thigh of the same; on the 24th above the left arm of Ophiuchus; on the 26th in the ecliptic at 220 degrees of longitude; on the 27th it disappeared between Virgo and Libra.

Struyck reports that Kindermann told him, in the letter referred to above, that the comet had been seen by three other persons besides himself: by secretary Kress, by a mathematician named Brukhard, and by a person whose name is not given, but who resided in the palace of the Count Brulaw.

When first seen on Feb. 2 we are told that the comet was equal in brightness to a star of the second magnitude, and that a tail, though not visible to the naked eye, was perceptible in a telescope.

The course of the comet seems difficult to follow, and one can hardly help suspecting that it may refer to two bodies instead of one. Kindermann named it Hetor, and fancied that it was a return of the comet of 1682 (Halley's). The orbit computed by Dr. Hind gives the perihelion passage as having occurred on Feb. 15, 1746, at a distance from the Sun slightly less than the Earth's mean distance. But one would like to know whether he used all the above observations or only those reported in Pingré.

Yours faithfully,

Blackheath, 1894, April 18. W. T. Lynn.

Mr. Tebbutt and the Transit of Venus, 1874.

Gentlemen,—

The only attempt I have yet seen on the part of Mr. Russell to answer the complaint which I made in the 'Australian Star' of his having ignored my work in connection with the

Transit of Venus, 1874, is that contained in the February number of your journal. The answer is, however, simply an attempt to disguise from your readers the real nature of my complaint. I did not call Mr. Russell's book a Government Report of the Transit of Venus, but referred to it as a *résumé* of the observations of the Transit of Venus made in 1874 under his direction. Twice in my letter of complaint I stated that I did not expect my observations to be included in the Report, but I certainly did expect that when he gave a brief account in the Introduction of what N. S. Wales had contributed as data to Captain Tupman's discussion in the 'Monthly Notices' he would do me simple justice. In the Introduction it is stated "There were thirty-one British observers of ingress, whose reports were available. Of these eight were from N. S. Wales, but after weighting and discussion, the total number was reduced to twenty. Of these eight received double weight, and of these double-weighted eight, two, Messrs. Scott and Russell, are N. S. Wales observers. At egress there were forty-eight observers, and again N. S. Wales furnished eight. After weighting and discussion, forty-eight are reduced to forty-one, but all the N. S. Wales eight remain, Vessey and Russell getting double weight, and Allerding, Capt. Hixson, Leuchan, Liversidge, Dr. Wright, and Tornaghi, single weight." Any one on reading this extract would naturally conclude that there were only eight N. S. Wales observers for each phase who had their observations discussed by Tupman, whereas there were really nine, and of each set of nine there were only three that received double weight, namely myself in addition to the two named by Mr. Russell. It will be seen at once that the proferred explanation does not meet the case at all, unless, indeed, that being myself outside the pale of N. S. Wales officialdom I have no right, as I said before, to be styled a N. S. Wales observer. I may add, in conclusion, that the wording of the preceding extract not only excludes myself as a N. S. Wales observer, but also disguises the circumstance that *five* out of his *eight* observers of the ingress had their observations rejected by Tupman.

Yours faithfully,
JOHN TEBBUTT.

Private Observatory,
Windsor, N. S. Wales,
1894, March 15.

PUBLICATIONS.

GREAT TRIGONOMETRICAL SURVEY OF INDIA, VOL. XV.—TELEGRAPHIC LONGITUDE OPERATIONS.—This recently published volume, prepared under the direction of Colonel Strahan, R.E., is an account in full detail of determinations of longitude between stations of the Indian Survey made in four seasons (a season apparently extending from November to March) between 1885 and 1892, and a revision of some earlier determinations, with a final discussion of the whole network from Peshawur in the north to Cape Comorin in the south, and from Quetta in the west to Moulmein in the east, which completes the Longitude Operations of the Survey. The final results are given as differences between stations and not as longitudes from Greenwich; but as the difference of longitude between Bombay and Kalianpur, which is the origin of the whole Indian Survey, has been determined, and the longitude Bombay—Greenwich was found by the telegraphic method, *viâ* Aden and Suez, on a previous occasion, the longitude of any place from Greenwich is given by simple addition.

The whole book is instructive and full of interest to experimenters, and longitude observers in particular. There are indications in parts of some disappointment,—disappointment from the fact that much long and tedious work done by observers of whose skill there was no question, and with obvious care, should, when finally reduced, have given results which at first did not harmonize as well as was wished and expected. But one appreciates first the foresight of General Walker who, as explained in Part III. of the volume, arranged the arcs in circuits, the "closing" of which should give a check on the results of more certainty than the individual probable errors of each arc, and secondly the ingenuity which detected and localized the source of error, thereby inducing a recomputation and finally more accurate results.

The facts are these. Between the years 1872 and 1884, several arcs of longitude were measured, each of which, judged by the usual method of probable error and consistency of results, would have been considered sufficiently accurate; but in combining these results to form circuits (it is obvious that of three longitude stations the sum of two of the differences of longitude should equal the third), errors were left outstanding which were larger than could be considered satisfactory. We might mention as interesting in connection with an outstanding error in the Paris—Greenwich longitude that, as an experiment, two telescopes were set up on the same meridian at Dehra Dûn, within a few feet of one another, and the whole procedure was gone through of measuring their difference of longitude, which should have been $0^s.00$, but the result came out $0^s.19$. The causes of these errors being sought, a fault in one of the telescopes was remedied, the cylindrical Y's were replaced by V-shaped ones, the instruments were overhauled and examined, and every precaution that care and experiment could suggest was taken. It was not until a late stage that the source of error was found in imperfect collimation, due to the faulty nature of the collimator object-glasses, which gave inconsistent errors, according as the collimators were placed so that the whole or part of the objectives were brought into use. The observations themselves gave means of correcting this error, a means of recomputation was evolved, and "the final results in this volume are given to the world in full confidence that their accuracy is probably as high as is possible of attainment with modern instruments." The details of operations may be sketched as follows:—The same stars, four groups of four on each night, were observed at both stations, the transits being recorded simultaneously on both chronographs, the difference of recorded times after correcting for instrumental errors and personal equation therefore giving the longitude affected only by time of transmission on the telegraph-line. Collimation was determined by two collimators, north and south of the transit pier, the cube of the telescope being pierced to allow of observation of one collimator by the other. Level was found by observation of the nadir, and Colonel Strahan points out the great advantage of using a trough for the mercury whose bottom is made of copper amalgamated with mercury. Azimuth error was found by observation of close circumpolar stars, except in a particular case at Dehra Dûn, where a distant mark was set up on the meridian capable of being illuminated at night. In some of the early determinations the telescopes were reversed on their pivots in the middle of a night's observations, but "subsequently it was decided that reversal more than counterbalanced the advantages aimed at," and in subsequent determinations the telescopes were not reversed during a night's work, but three nights of a series were observed with "Illuminated pivot east," the other three with "Illuminated pivot west."

Observers at the ends of an arc were not interchanged, except in one case for experiment. Difference of personal equation was determined at intervals by direct comparison, the two observers observing the same star at the same transit, one over the first half of the wires of the reticule, the other over the remainder. Interchange of observers, in the usual sense, is probably of no import in a network of this kind, where the final discussion of arcs would probably eliminate any undetermined absolute personal errors.

The final discussion, in which assumed errors of the 55 measured arcs are used as unknowns in a series of equations formed with circuit errors as constants, gives satisfactorily small values of these errors—three lie between $0^{s}{\cdot}040$ and $0^{s}{\cdot}045$, six between $0^{s}{\cdot}030$ and $0^{s}{\cdot}040$, and the rest are smaller. The comparison between geodetic and astronomical values of the arcs gives some differences which, at first sight, look surprisingly large; but the next chapter on local attraction, which discusses these differences, shows that they result from considerable zenith deflections at some of the stations, and gives a value of the Earth's equatorial radius in closer accordance with Col. Clarke's value than that hitherto adopted, and also provides some evidence in favour of Col. Clarke's theory that the Earth's equator is an ellipse of small eccentricity.

There is an interesting paragraph on the time of transmission of the signal along the telegraph-wire. As there was considerable range in the length of the different lines of wire used, it was possible to form equations and determine a formula for time of transmission.

Col. Strahan finds :—

(1) If the time of transmission be a function of the length of time to the second power,

$$\text{Time}=0^{s}{\cdot}023+0^{s}{\cdot}00537\times l+0^{s}{\cdot}00047\times l^{2}.$$

(2) If it be a function to the first power only,

$$\text{Time}=0^{s}{\cdot}007+0^{s}{\cdot}01129\times l.$$

The unit of l being 100 miles.

In these formulæ the first term on the right-hand side is taken as the "armature" time.. Both agree well with the actual facts, but they give larger values than those obtained in previous investigations, and we believe larger than those found in recent longitude operations from Greenwich. A formula adopted by German geodesists is

$$t=0{\cdot}00129\, l+{\cdot}00008\, l^{2}.$$

PRINCIPIA NOVA ASTRONOMICA *.—There is no doubt but that Dr. Pratt intends his work to be taken seriously, the paper, diagrams, printing, and binding are befitting a *magnum opus*, a classic work to last through time; and assuming Dr. Pratt's serious intent we try to conceive his reason for thinking that the world will give up the present accepted theory of cosmogony to accept Dr. Pratt's, which he here lays before us.

The first article of Dr. Pratt's faith, and about which he seems to think that he is at issue with astronomers, is that the Sun moves in an orbit. We fancy that no one denies that the Sun may so move, but that there is not at present sufficient evidence accumulated from observation to decide the fact. Dr. Pratt, superior to observational evidence, says: "When the discovery was made that the Sun rotates on its axis while advancing in the heavens, the fact that it revolves in an orbit ought to have been recognized, for axial rotation necessarily causes the path of an advancing body to be curvilinear. The orbital motion of the Sun is thus virtually demonstrated." This method of assumption is typical of the book; after assuming the revolution of our Sun about a body called the "Equatorial" Sun in a period of 18·6 years, this period being adopted to account for nutation, we are asked to accept another Sun called the "Polar," about which the Equatorial revolves in a period of 25,800 years, to account for precession, and then beyond this another called the "Central" Sun, towards which the Earth's axis is continually directed and about which the Polar Sun revolves. At this point we were preparing to expect another Sun for the Central to revolve round, and another, and another, the only limit we could anticipate was that the names to be ascribed to them would not hold out—but no, on page 62 Dr. Pratt stays his creative hand, and says: "Is the Central Sun moving in space? Possibly. Indications in this regard are absolutely wanting." We wonder at his forbearance!

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* 'Principia Nova Astronomica' by Henry Pratt, M.D. Williams and Norgate: London, 1894.

We have not space to attempt to controvert the author's errors. He agrees with some other persons in thinking that the Moon does not rotate on its axis, and also he is of opinion that the Earth's polar diameter is longer than the equatorial, which he thinks is proved by the fact that a degree of latitude is longer at the poles than at the equator, an opinion which argues that Dr. Pratt's knowledge of geometry is somewhat superficial. But in the hope that this may meet the eye of some one about to write a similar book, we may point out that it is lost labour to elaborate a theory to replace an accepted one, unless it will satisfy the observed facts with *more* accuracy than the accepted theory. And this Dr. Pratt has not attempted to show.

We have received from Messrs. Philip and Son a little pamphlet of 27 pages dedicated to the members of a Working Men's College, giving a short history and a vocabulary of our science. The history is just a brief chronological record, and would be found useful for reference by those who have a difficulty in remembering dates. We notice one little inaccuracy. Maskelyne is called the *fourth* Astronomer Royal; the author has forgotten Bliss. We might protest against Vulcan being put in a list with the planets, although with a ? affixed, as likely in a book of this kind to cause misconception. This work is sold for sixpence, and is quite worth that small sum.

NOTES.

Comet Notes.—The following orbit has been published of Denning's New Comet, 1894 *a*. It is by Prof. Krueger.

T = 1894 Feb. 13·1134 Berlin M.T.

π	132° 6′ 21″·6	1894·0.
☊	75 50 55·1	
i	6 31 29·5	
q	1·2147	

The small inclination suggests periodicity, and on examining the catalogue of comets it was found that the (only roughly known) elements of the comets of 1231 and 1746 (Kindermann's) show some resemblance to the above. They are given below, the computers being Pingré and Hind respectively.

T =	1231 Jan. $30^d\ 7^h\ 22^m$ Paris M.T.	1746 Feb. 15^d·0 G.M.T.
π	134° 48′	140° 0′
☊	13 30	335 0
i	6 5	6 0
q	0·948	0·95

All the above apparitions could be explained by a period of between 73 and 74 years. If the identity be established the comet must have greatly declined in brilliancy since 1746, when it appeared as bright as a second magnitude star.

Unfortunately the brightness is now rapidly declining, but it is to be hoped that observations will be possible for a sufficiently long period to settle the question of identity. The following is an ephemeris for Berlin midnight.

	R.A.	N. Decl.		R.A.	N. Decl.
	h m s	° ′		h m s	° ′
April 26..	11 18 28	17 2	May 8..	11 40 14	12 33
30..	26 5	15 27	12..	46 53	11 12
May 4..	33 18	13 58	16..	53 19	9 55

The brightness on April 26 is ¼ and on May 16 ⅑ of that at discovery.

The following sweeping ephemeris of Tempel's Comet (1873 II.) is by M. Schulhof:—

	R.A.	S. Decl.		R.A.	Decl.
	h m s	° ′		h m s	° ′
May 3..	23 27 50	5 55	June 4..	1 5 58	0 4 S.
11..	23 53 39	4 20	12..	1 28 8	1 6 N.
19..	0 18 39	2 50	20..	1 49 19	2 6 N.
27..	0 42 47	1 23			

There is a probable error of some 4^m in R.A. and 10′ in N.P.D. The comet is much more favourably placed for observers in the southern hemisphere than in Europe.

A comet was discovered by Mr. Gale of Sydney, its position at 11 A.M. on April 3 being $2^h\ 30^m\ 48^s$, S. Decl. 55° 35′; motion easterly. It is described as round, bright, with condensation. From observations at the Cape Observatory on April 11, 12, and 13, Prof. Kreutz has deduced the following elements and ephemeris (for Berlin midnight):—

$$T = 1894 \text{ April } 13{\cdot}8558 \text{ Berlin M.T.}$$

$$\left.\begin{array}{ll} \omega \ldots\ldots & 324^\circ\ 17'{\cdot}90 \\ \Omega \ldots & 206\ \ 8{\cdot}59 \\ i \ldots\ldots & 87\ \ 24{\cdot}39 \end{array}\right\} 1894{\cdot}0.$$

$$\log q \ldots\ \ 9{\cdot}99370.$$

	R.A.	Decl.		R.A.	N. Decl.
	h m s	° ′		h m s	° ′
May 3..	8 16 20	7 42 S.	May 15..	9 53 27	24 50
7..	8 56 11	6 41 N.	19..	10 14 8	30 48
11..	9 27 56	17 24 N.			

From this it will be seen that the comet will be well placed in May for European observers. The brightness is at a maximum on April 29, being then six times that at discovery; on May 15 it is about twice that at discovery.

In Ast. Nach. 3218 Dr. Cohn investigates the orbit of Comet 1885 V. (Brooks); the observations cover a period of two months from 1885, Dec. 28, to 1886, March 1. The following is his final orbit:—

T = 1885 Nov. 25·547149 Berlin M.T.

$$\left.\begin{array}{lrrr}\omega\ \ldots\ldots & 35^\circ & 37' & 20''\!\cdot\!53 \\ \Omega\ \ldots\ldots & 262 & 12 & 2\ \cdot 97 \\ i\ \ldots\ldots & 42 & 26 & 32\ \cdot 30\end{array}\right\}\ 1886\cdot 0.$$

$\log q$ .. 0·0332745

No decided deviation from a parabola is indicated.

The following cometary orbits are investigated in the 'Publications of the Kiel Observatory,' No. IX.:—

No. 1. Definitive orbit of Comet 1891 I. by Prof. Lamp. This comet was discovered almost simultaneously in March 1891 by Prof. Barnard and Mr. Denning. It quickly ran south, and could only be observed for a fortnight in Europe before it was lost in the sunlight. But after perihelion passage a valuable series of observations was secured by Mr. Tebbutt at Windsor, N.S.W., and also at the Capetown and Cordoba Observatories. It was last seen on July 9 at Cordoba, being then on the extreme limits of visibility. Over 100 observations are available, but to several no weight is given, either owing to unfavourable conditions noted by the observers or to large outstanding errors. The following is the final (parabolic) orbit:—

T = 1891 April 27·558209 Berlin M.T.

$$\left.\begin{array}{lrrr}\omega\ \ldots\ldots & 178^\circ & 45' & 20''\!\cdot\!72 \\ \Omega\ \ldots\ldots & 193 & 56 & 2\ \cdot 90 \\ i\ \ldots\ldots & 120 & 31 & 29\ \cdot 88\end{array}\right\}\ 1891\cdot 0.$$

$\log q$ .. 9·5997697.

Perturbations by Jupiter, the Earth, and Venus are taken into account.

No. 2. Definitive orbit of Comet 1873 V. by Prof. Kreutz. This comet was discovered by M. Paul Henry at Paris, Aug. 23, 1873. Numerous observations were secured up till Sept. 16, after which it was lost in the sunlight. It was again seen at Pola on Nov. 28 and Dec. 17, but the observation on the latter day was too rough to be employed. The perturbations by the Earth, Jupiter, and Saturn are computed and applied. The observations give evidence of large systematic errors of some observers, a point which has often been noticed before, and which is not at all surprising considering the complicated structure and irregular shape of many comets. The following is the final parabolic orbit:—

T = 1873 Oct. 1·8003804 Berlin M.T.

$$\left.\begin{array}{lrrr}\omega\ \ldots\ldots & 233^\circ & 45' & 4''\!\cdot\!38 \\ \Omega\ \ldots\ldots & 176 & 43 & 25\ \cdot 22 \\ i\ \ldots\ldots & 121 & 28 & 53\ \cdot 00\end{array}\right\}\ 1873\cdot 0.$$

$\log q$ .. 9·5852640

The most probable ellipse has a period of 53,919 years.

Dr. Backlund has published two valuable memoirs on Encke's Comet, the first containing tables for computing the eccentric anomaly and the radius vector of the comet, and the second being an examination of its perturbations by Venus, the Earth, Mars, Jupiter, and Saturn, between 1871 and 1891. They form Vol. xxxviii. No. 8, and Vol. xli. No. 3, of the 'Memoirs of the St. Petersburg Academy of Science.'

In Ast. Nach. 3222 Dr. Vogel notes, with regard to the article by Prof. Kayser recently referred to in these columns, that he himself has pointed out the effect of a wide slit on a banded spectrum when the light maximum is at one end of the band, so long ago as 1881, in an article on the bright comet of that year. While admitting its applicability in many cases, he considers that his other explanation, viz. that comet spectra are a mixture of the hydrocarbon and carbon monoxide spectra, is still required to explain some anomalies.

Comet Holmes was in opposition in January last, and a careful search was made at Washington, both in December and January, with a 10-inch refractor, but without success; the possibility was recognized of its appearing as an asteroid without a nebulous envelope, but nothing of the kind could be detected.

The Russian Astronomical Society are undertaking the calculation of the true path of Halley's Comet in order to predict the circumstances of the next return, which is due in about sixteen years. Should any of our readers know of any unpublished observations of this comet they are requested to communicate them. A. C. D. C.

OBSERVATIONS OF JUPITER'S SATELLITES.—It will be remembered that at the beginning of last year Prof. W. H. Pickering published some papers giving his observations of Jupiter's satellites, at Arequipa, with a telescope having an objective of 13 inches diameter, which had led him to believe that the discs of these bodies were not circular but of elliptical shape. Since his return to the Lick Observatory, Prof. E. E. Barnard, with Mr. Burnham, has been observing these satellites with the 36-inch, with the view of verifying, if possible, Prof. Pickering's conclusions. He publishes his observations in 'Astronomy and Astro-Physics' for April, and on all of the 14 nights on which he observed he could not see the discs other than circular. He agrees that the satellites, when in transit, may appear distorted owing to surface-markings which are indistinguishable from the body of the planet, and describes appearances seen by him on different nights where this fact was obvious. Prof. Barnard also adds observations negativing the supposed transparency of the limb of Jupiter. He says: "I think it is high time that astronomers reject the idea that the satellites of Jupiter can be seen through his limb at occultation. When the seeing is bad there is a spurious limb to Jupiter that might well give the appearance of transparency at the occultation of a satellite. But under first-class conditions the limb of Jupiter is perfectly opaque. It is quibbling and begging the question altogether to say that the phenomenon of transparency may be a rare one, and so have escaped my observation. Has any one said yet that the Moon was transparent when a star has been seen projected on it when it ought to have been behind"?

For the following ingenious graphical method of solving a spherical triangle we are indebted to M. R. Radau, of the Paris Observatory, who published it in the 'Bulletin Astronomique' for February last.

Using the usual notation for a triangle, if the Cartesian coordinates of three points are respectively $1, \cos(a+b)$; $-1, \cos(a-b)$; and $\cos c, -\cos C$, these three points lie on a straight line, because the ordinary formula for a spherical triangle

$$\cos c = \cos a \cos b + \sin a \sin b \cos C$$

is easily transformed to

$$\frac{\cos \overline{a+b} - \cos \overline{a-b}}{1-(-1)} = \frac{\cos \overline{a+b} - \cos c}{1-(-\cos C)}.$$

So that if a square be formed with its edges graduated according to the cosine law from 0° to 180°, the origin of coordinates being at the centre of the square, this point representing the 90 degree mark on both the horizontal and vertical axes, then a, b, and C being given, if a straight line be drawn from the points marked $\overline{a+b}$ $\overline{a-b}$ on the two vertical scales, and the point on this line whose ordinate is $-$C be noted, the abscissa of this point will give c. Similarly the line joining the points marked A+B, A−B on the horizontal sides of the square will pass through the point $-$C, c. And since the sine of an angle may obviously be read off the scales as easily as the cosine, having got a, b, c, and C, and using the formulæ

$$\frac{\sin a}{\sin A} = \frac{\sin b}{\sin B} = \frac{\sin c}{\sin C},$$

the angles A and B can be found by drawing lines through $90-a$, $90-b$, parallel to the line joining $90-c$ to $90-$C.

Practically the objection to an abacus of this kind is its size, which becomes unwieldy if it is to be large to give results of a moderate degree of accuracy; if the side of the square be as large as 3 feet, the ten degrees at either end of the scale would be represented by a length a little more than a quarter of an inch. The first purpose which occurs to us to which this calculating machine could be put is the computation or perhaps the checking of the computations of the latitude of Sun-spots from their measured polar coordinates. In this case there would be this advantage, that the quantity c which is sought would always be at a part of the scale of large dimensions, when the reading to tenths of a degree would be comparatively easy.

Prof. Schaeberle has followed up his mechanical theories of the corona and of comets by a mechanical theory which he purports to be an explanation of the formation, motion, and periodicity of Sun-spots. He publishes this in 'Astronomy and Astro-Physics' for April, and in the hope of finding a clue to the solution of one of the most interesting problems now before the astronomical world, we have read this with some care and trust we are not missing the point of Prof. Schaeberle's theory in the following brief criticism.

Prof. Schaeberle begins by telling us that in a non-rotating incandescent liquid there would be ascending and descending currents, and that *at any given instant the temperature, density, and radial velocity at the surface of any given spherical shell within the body will be the same at every point of the shell.* We are unable to see how *all* the matter at the surface of a shell could be moving either inwards or outwards at the same time.

Then follow some tables of sin θ cos θ and $\cos^2\theta$ for different values of θ, which are (we suppose) connected with the fact that a particle on a sphere in latitude θ has an acceleration varying as cos θ towards the axis, and by resolution this gives acceleration proportional to $\cos^2\theta$ radially and sin θ cos θ tangentially. And by help of these relative velocities of adjacent zonal elements Prof. Schaeberle considers what would happen if a spherical mass of fluid at rest were set (by some means or other) moving about an axis. He deduces certain laws about zonal waves, overlooking the certain fact that the form would become spheroidal. As he here says nothing about the effects of cooling, there is no reason at all why the mass should not merely take a spheroidal form by the particles flowing towards the Equator.

But having thus evolved a system of "zonal waves" Prof. Schaeberle says:—"Applying this new principle of zonal-wave motions to the theory of our Sun, a very simple explanation of the hitherto puzzling phenomena of the periodicity and motions of the solar disturbances is obtained." We have looked in vain through the rest of the article for any figures or statements which are at all consistent with observed solar phenomena, and we find nothing except such general statements as "the general flow towards the Equator will for a time be retarded in latitudes greater than that of the zonal crest, and accelerated for lower latitudes"; and "the interval of time between two successive similar phases in a given zone will depend upon the fluidity of the mass and the velocity of rotation. For a mean surface velocity of three miles per hour (towards the Equator) the periodic time will be about eleven years in the case of a body as large as the Sun."

We confess a dislike to Prof. Schaeberle's airy way of treating mechanical problems. A good deal has been written on the vibrations of rotating masses of fluid. The subject is a very difficult one and has received the attention of M. Poincaré, Mr. G. H. Darwin, Mr. Lamb, and others, and we are bound to say we should refer to their papers rather than to Prof. Schaeberle "for laws based on purely mechanical principles which are probably true throughout the whole Universe." There may be zonal waves on the Sun, but Prof. Schaeberle's paper does not convince us of their existence; and there may be other kinds of waves, and Prof. Schaeberle's paper does not convince of their non-existence.

F. W. D.

We learn from 'Ciel et Terre' for March that observations of atmospheric electricity were made last year during a period of six months (1st May to the 2nd November), near the summit of the Eiffel Tower, at the height of 285 mètres (935 feet) above the surface of the ground, and registered photographically by means of a Richard self-recording instrument. A comparison of the curves obtained during this period on the tower with those recorded at the Bureau Central Météorologique, Parc-St.-Maur, shows a simplification of the diurnal curve, the double wave usually met with in the records made on or near the surface o the earth giving way at the elevated station to a curve with a single inflexion, the maximum being attained at night and the minimum in the morning.

Dr. Gill announces the discovery of a variable star of short period in the constellation Vela. The star is given as No. 13052 in the Cordoba General Catalogue, R.A. $9^h\ 28^m\ 30^s{\cdot}6$, Dec. $-44°\ 39'\ 19''$ (1875). Measures of its photographic image give a period of $5^h\ 22^m\ 19^s \pm 6^m$. The brightness varying from 9·3 to 7·7.

We hear that Messrs. Philips & Son are about to publish a map of the Moon, prepared by Mr. Gwyn Elger. This map, which will show our satellite with a disc of 18 inches diameter, is to be a copper-plate engraving, and will be accompanied by letterpress descriptive of the principal formations. No doubt many of our readers will be glad to secure a copy of this work from the hands of our great English selenographer.

With reference to an article by Prof. W. H. Pickering on p. 173, it is announced that an expedition to some station in Arizona is being organized for the purpose of observing Mars at the favourable opposition next summer. The cost of the expedition is to be defrayed by a private astronomer of Boston.

Meteorological Observations taken during the Year 1892 at the Royal Alfred Observatory, Mauritius.—The Annual Volume of this Observatory has just been issued. It consists of a closely-printed Blue Book of 123 pages, and contains a large mass of tabular matter giving detailed information with regard to the climatic conditions of the colony, with a completeness which has marked the work of this Observatory for many years.

Visitation Day at Greenwich will be on June 2 this year. The dinner after the Meeting will take place, as in recent years, at the Criterion, Piccadilly Circus.

An announcement circulated on April 9, to the effect that a bright comet had been discovered in Draco, was unfounded.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 215. JUNE. 1894.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, May 11, 1894.

Capt. W. de W. Abney, C.B., F.R.S., *President*, in the Chair.

Secretaries: Prof. H. H. Turner, M.A., B.Sc., and
E. W. Maunder.

Mr. Maunder read the Minutes of the last Meeting, which were confirmed.

Mr. Maunder. 71 presents have been received since the last Meeting, none of them calling for any special notice, except a series of lantern-slides from the Sydney Observatory, presented by Mr. H. C. Russell.

Prof. Turner then read an abstract of a paper by *Dr. Gill*, which was announced at the last Meeting but not read, owing to the pressure of other papers. After giving some account of his heliometer observations of the minor planets Victoria and Sappho, and the value of the solar parallax $8''\cdot799 \pm 0''\cdot005$ deduced therefrom, Dr. Gill suggested that a Congress of Astronomers should be held in 1896 for the purpose of co-operation in improving observations in certain fundamental particulars, which he detailed. Prof. Turner stated that these suggestions were under the consideration of the Council.

Capt. Noble. It seems to me there is one weak point about this method of determining the solar parallax. There is no doubt it is very much easier to measure the distance of a planetoid, which is undistinguishable from a fixed star, from an actual star, than it is to measure the distance of the centre, or in practice the limb, of a planet like Mars from one. Therefore this method of obtaining parallax would be superior to that in that sense. But the orbits ought to be uncommonly well known, and they should be preferably circular, in order that we may know precisely the position of the planet relatively to the Earth at the time of observation. I forget the exact excentricity of the orbits of Victoria and Sappho, but I believe it, in each case, to be considerable. Unless one does know exactly the position of the planet itself you may measure its distance from a fixed star as exactly as you please, and you will only get an approximate parallax in the end. That seems to me the matter of doubt about any absolute parallax obtained in this manner.

Mr. Stone. The smallness of the residual errors is a sufficient proof of the very great accuracy with which the distances between these small planets and the stars have been fixed by the heliometers in these observations. But the direct effects of small errors in the solar parallax on these measured distances is but small. And I can hardly regard the probable errors of the resulting values in the solar parallax as fairly representing the real errors of such determinations. In all these cases we have not only to determine from observation the ratio of the equatorial radius on the Earth to the "unit distance," but also the ratio of the mean distance of the planet from the Sun to the "unit distance." And I can hardly share the sanguine views of Dr. Gill that the latter's ratio is fixed, in these cases, without sensible errors. In fact I believe this is not possible until the theory of the planet's motion has been brought to a state of sensible accuracy. And this can hardly be the case with these asteroids, even if it is true, which I doubt, for the planets which have been much longer under regular observation. It is, however, to my mind, satisfactory to find that in all the best recent determinations the values of the solar parallax are confined within some such limits as 8″·80 and 8″·88. For the reasons given I lean to the adoption of the mean result from several different methods rather than to that obtained by a single method, however small the residual errors may appear.

Mr. Knobel. The results Dr. Gill has obtained I think are very remarkable indeed. I understood from the paper that this is a refinement upon his previous determination of the solar parallax*. With regard to the proposition Dr. Gill has made for an International Conference to consider more exact methods of astronomical observation, that is a point on which it would be premature to express an opinion at the present moment; it is one which must be considered very carefully indeed before arriving at a conclusion. There is doubtless a great deal to be said in favour of astronomers meeting together and conferring as to methods of observation; at the same time there is also a question as to whether much may result from such a conference. However, the paper seems to me full of suggestions and full of matter which we should carefully consider before making up our minds to any definite conclusion. I think it is an extremely valuable paper in its suggestiveness as well as in the remarkable facts arrived at from the very great number of observations made to obtain this value for the solar parallax.

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* Dr. Gill writes me: "The labour has been immense. It has turned out that the observations are more exact than Le Verrier's Solar Tables, so much so that new solar phases have had to be computed by special perturbations and osculating elements employing 8-figure logs, and similarly the planet's heliocentric ephemeris, and all the work of the geocentric ephemeris carried out with 8-figure logs, the lunar perturbation of the Earth and its effect on the geocentric place of the planet being computed for each day. Then all the interpolations have had to be done over again, and all the tabular distances and position-angles recomputed. But the result is that the residual errors are diminished by one half. The mass of the Moon comes out with great exactness $\frac{1}{8\cdot19}$; a result which will most materially affect the whole system of our astronomical constants."—E. B. K.

Dr. Isaac Roberts then exhibited on the screen a photograph of the Nebula M 78 and ♅ IV. 36 Orionis. It was taken with a 20-inch reflector on Jan. 28, 1894, with an exposure of the plate during 3 hours. The nebulæ are numbers 2068 and 2071 in the New General Catalogue, and 1267 and 1270 in the General Catalogue. Both nebulæ were described by Herschel in the 'Philosophical Transactions of the Royal Society' for 1833.

The photograph showed that the central part of the nebula was like a dense cloud with a well-defined margin on the north preceding side, and the three stars referred to by Herschel were shown involved in the nebulosity. The nebula ♅ IV. 34 had a stellar nucleus with a faint companion star close to it on the south side, and this double stellar nucleus was surrounded by streaky cloud-like nebulosity. There were indications that the two nebulæ were connected together with very faint nebulosity; but there was no spiral form, as suggested by Lord Rosse, visible in either of them.

The sky was remarkably devoid of stars within half a degree of the nebula, but beyond that distance, both preceding and following, the stars were crowded on the plate.

Photograph M 74 Piscium was taken with exposure of $3^h 40^m$ with the 20-inch reflector on Dec. 9, 1893. The nebula is No. 628 in the New General Catalogue and 372 in the General Catalogue. Quoted by Herschel and Lord Rosse. The photograph showed the nebula to be a very perfect spiral, with a 15-mag. star close to it on the south side. The convolutions of the spiral were studded with many stars and star-like condensation, and on the north preceding side there was a partial inversion of one of the convolutions, which conveyed the idea of some disturbing cause having interfered with its regular formation. The photograph could not be adequately described; it must be examined before it could be appreciated.

Mr. Knobel. I should like to ask Dr. Roberts if the star with a faint companion in the nebula M 78 is the double star discovered by Burnham?

Dr. Roberts. I am not sure about it, but he ought to have been able to see it.

Mr. Knobel. I am surprised that in that nebula two more stars are shown. With regard to the cluster M 74 I have a drawing here* of this nebula which I made some 22 years ago, and upon which I bestowed many nights' observation in order to determine the relative magnitude of the stars. They do not accord in magnitude with those on the photograph. The relative magnitudes of the stars were delineated with as much accuracy as several nights' observations would produce. I assume that the long exposure of the photograph may have tended to equalize the magnitudes.

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* The drawing was handed to the President.

Col. Herschel. Does that refer to one or two stars only?

Mr. Knobel. It refers to several of the stars. In the photograph so many stars are about the same magnitude, but in the drawing many differences are shown.

Col. Herschel. Would it not be worth while to estimate the magnitude of the stars on your drawing and put it in a form for direct comparison, star by star?

Mr. Knobel. The drawing is a chalk one, and will not photograph.

The President. The positions are exactly similar, but the magnitudes are very different.

Col. Herschel. My reason for asking that is that I have so frequently found, on comparing the existing state of any field with a chart of former times, that the magnitudes seem very greatly different.

Dr. Johnstone Stoney. I think we must always make some allowance for the difference of the apparent magnitudes of stars in a photograph and in an eye observation. I was much interested in the dark lines that are shown on the photograph near the nebula, and especially from the circumstance that they occur in the constellation of Orion, for I recollect remarkable instances of dark lines and spaces being observed by eye observations in other nebulæ in that constellation. The most conspicuous was in the nebula which surrounded the double star ι Orionis, according to observations made about 1850 with Lord Rosse's 6-foot reflector. With respect to the form of the nebula M 78, as noticed in Lord Rosse's observations, I think it easy to see how the appearance may have presented itself. When the photograph was on the screen I partially closed my eyes, and it did then seem to present a spiral form. Dr. Roberts's photograph seems almost with certainty to imply that the whole general field of view contains nebulosity, and that there are only small gaps which are free from it. Similar dark spaces have also been seen in connection with the central parts of the great nebula in Orion, especially one forming what has been called the mouth of the fish; moreover, eye observations with Lord Rosse's great telescope gave me the impression that faint nebulosity extended over an immense area and connected all the nebulæ in the constellation of Orion. It is remarkable that the dark spaces in this nebulosity seem always to be met with close to those denser wisps which are usually regarded as distinct nebulæ, and especially when we bear in mind what an immensely long tube must exist in the direction of the line of sight through the nebulosity to produce the appearance of a dark space.

Prof. Turner. I have not heard it remarked to-night that this dark space and wisp of nebula has a distinct resemblance to the picture Dr. Roberts has taken of the Andromeda nebula and the satellite thrown off from it.

Dr. Roberts. With regard to the spiral nebula, I never adopt the word "spiral" unless it is clearly shown, and in the spiral nebulæ (several of which have been shown to the Society and several I have at home which have not been shown) the spirals are so distinct that there can be no two opinions concerning them. In this case I should not like to call the nebula a "spiral" after seeing the others. Mr. Ranyard points to the stars in the spirals. Every one of the spiral nebulæ has numerous stars which are all or nearly all involved in the convolutions. This is only one out of several examples, but they all have the same characteristics. The spirals are generally perfect, and they are broken up into star-like condensations. The reason for this appearance may be suggested in two or three different ways, but I do not commit myself to either of them until the evidence is strong and beyond contradiction. One of the suggestions is that two streams of meteoric or of other material composition might come in contact whilst moving in space from opposite directions, and their margins colliding, with the result that friction would cause a spiral motion. You may take this for what it is worth; I do not put it forward dogmatically, but as one of the suggestions.

The President. These very excellent photographs have given us very much instruction. We are now getting a new development of meteor-swarms, which will require very careful attention.

A vote of thanks was accorded to Dr. Roberts.

The Astronomer Royal gave a short *résumé* of a paper by *Dr. Hermann Struve,* which did not lend itself well to description, as it consisted mainly of numerical results. Dr. H. Struve had been engaged for some time with the 30-inch Pulkowa refractor in making observations of the satellites of Saturn. In the paper he discussed the various measures of the diameter of Saturn which had been made by previous observers, and he added his own measures. Some of them were made by direct measurement with the 30-inch refractor, and others were deduced from measures of satellites from the two limbs and also observations of the eclipses of satellites. These observations had been of very much interest, because the eclipses of satellites had hardly been observed until recent years. Mr. Marth had computed ephemerides of satellites from which he had predicted eclipses, and these had been observed by Dr. H. Struve, Prof. Young, and the Rev. A. Freeman. Dr. Struve was very much struck with the discordances of the observations which he got of the diameter of Saturn with the same instrument and the same observer. He got differences of $0''\cdot3$ or $0''\cdot4$ in the diameter. He had calculated the measures of the diameters made by different observers with different instruments and with different methods of observation, with the heliometer as well as with the filar micrometer, and he found they differed considerably, which might be due to irradiation or to the telescope used. It was remarkable that Dr. Struve's own observations should differ *inter se* to such a large amount.

Mr. Stone. Is there any law in the differences?

The Astronomer Royal. They are different according to the satellite which was used in the measures. These measures were not made directly from observation of the diameter of Saturn, but indirectly for the determination of the distances of the satellites.

Prof. Turner. This paper is regarded by the author as a sort of complimentary contribution to the Society on the occasion of his being elected an Associate.

A vote of thanks was given to Dr. Struve.

Prof. Turner then exhibited the photographs, sent by Mr. Russell from Sydney, of the region about η Argûs and other stellar fields, taken either with the astrographic telescope or with a portrait-lens. There was also a remarkable photograph of lightning taken on a plate exposed for four minutes, showing many lightning-streaks apparently entering the water in Sydney Harbour.

Mr. Knobel. The most remarkable thing is that the lightning apparently endures for a long time.

General Tennant. That lightning is more like what I have seen in India—where you do see it endure—than anything I have seen elsewhere. It is *really* lightning. It did not last 4 minutes, but it lasted long enough to enable you to trace the form.

Dr. Spitta. Is that one flash or more?

Gen. Tennant. Only one; at least the flashes are so nearly simultaneous that you can hardly say whether they are merely coincident flashes or branches; but one flash lasts decidedly a considerable time.

Dr. Spitta. But this goes into the water.

Gen. Tennant. I never saw a flash over the water, but I have seen flashes come down to the ground and I have seen them last. Conducting ground is often struck. There was a hill near Madras which was often struck and there was a barrack at Jutogh which was more than once struck. In Mussoorie there was a Bank house which was struck whenever we had any great lightning, and in the Madras case I believe it was traced to a ferruginous soil—a soil very strongly impregnated with iron underneath it; whether that is the case or not I will not say, but I am certain that in certain places where there is conductive matter the place was liable to be struck.

Mr. Ranyard. That looks very much as if the flashes proceeded from the place where there was a good conductor; the flashes in this case become less bright in the lower part of the field than in the upper—appearing, therefore, as if they commenced from the lower part.

Gen. Tennant. I am as certain as I am of anything that I have seen in a short space of time, and that a pen could not make at once a note of, that flashes start from below and travel upwards as well as from above travelling downwards.

Capt. Noble. I should like to say that you need not go to India to see lightning come out of the earth. I myself have seen it do so from the top of Crowborough Beacon, the highest point in Sussex, whence, in a very heavy storm, I distinctly saw a flash of lightning strike up from the ground to the sky. The late Mr. Proctor always denied that it could be seen whether lightning came down from the clouds or up from the earth, but if I did not see lightning strike up on that occasion I never saw anything in my life.

Dr. Roberts. The photographs presented by Mr. Russell are interesting; those of them with a short-focus lens cover a large area of the sky which appears to be crowded with stars, but when we compare the photographs taken with the astrographic instrument, which has a focal length of 11 feet 4 inches, with them, the number of stars shown on a selected area is over 1000, whereas the same area on a photograph taken with the portrait-lens shows only 80 stars. We should bear this in mind when admiring the number and brilliancy of the star images taken with the portrait-lens, that the much less striking picture produced by the larger instrument has, nevertheless, twelve times the number of stars upon it. It is the close proximity and great enlargement of the star discs on the portrait-lens picture that give the brilliancy to it and make it so interesting to spectators. I notice that Mr. Russell has not adopted the method of backing the plates. The star discs would be improved if the plates were backed, as the halation circles round the bright stars would be avoided.

Mr. Maunder. I should like to call the attention of the Fellows to Mr. Russell's tenth slide. This represents the star-cluster 3315, about which Mr. Russell presented a paper read at the last meeting of the Society. The exposure was for 8 hours. It is the most brilliant star-cluster in the Southern Hemisphere, and Mr. Russell gave it this long exposure to ascertain if there was any nebulosity to be discovered in it like those which have been discovered in the Pleiades and many other star-groups. The result shows that it is entirely free from any nebulosity which can be detected by an exposure of this length—a result of considerable importance when we remember what an immense amount of nebulosity in unexpected quarters has been revealed of late by long-exposure photographs.

A vote of thanks was passed to Mr. Russell.

Mr. F. W. Dyson then gave on the blackboard the methods and results of the work undertaken by himself and Mr. W. G. Thackeray, given in their paper "The Effect of Personality in Observations of the Sun's R.A. on the determination of the position of the Ecliptic."

Mr. Thackeray. As Mr. Dyson has explained the theoretical side, I might briefly explain the practical bearing of the question. It is well known that different observers estimate differently the time when a star appears to be bisected by the wires in the telescope, and such differences are called personal equations. In referring all Right Ascensions to the Sun it is tacitly assumed that an observer in finding the time of transit of the centre of the Sun (which is obtained by taking the mean of the times of transit of the preceding and following limb) has exactly the same personal equation in estimating the time when either limb is a tangent to the wire as he had in estimating the moment of bisection of the star's image by the wire. The purpose of this paper is to show that such an assumption is very far from being even approximately true, and that the resulting corrections are large, fairly constant for any one observer, but liable to great changes whenever the observers are changed. The extreme range between two observers is about $0^s \cdot 2$, so that were it to be assumed that one observer were to make all the observations of the Sun in one series of years and another over another series of years, one would be suddenly confronted, when these two observers were changed, with a large correction to the equinox of $0^s \cdot 2$, which would be intolerable. You may say, when you have four or five observers, that the mean of such a variation would remain fairly constant, and, practically, for a number of years such has been the case; or at any rate the variation has not been serious; but now the latest changes in the staff at Greenwich have brought together observers having large personalities all on one side of the previous means, and the disease has reached an acute stage; the consequence is when the 5-year catalogue, which is about to be published, was under discussion the amount of correction for the Equinox came out at $+0^s \cdot 043$, which, following precedent, ought to have been applied, but the Astronomer Royal considered that that was too large a correction to make in only a provisional catalogue, and thought it best to leave the question for discussion when the next general catalogue is made. Apparently there are exactly the same sort of differences at Washington as there are at Greenwich. The main difficultly then becomes, what is to be the standard to which you must refer in order to get an absolute zero of Right Ascension? You must refer to something, and the question is what are you going to refer to?

The Astronomer Royal. The great point is that hitherto in the Greenwich system we have adopted for our zero the mean of results as found by a number of regular observers, and we have trusted to the means coming out right. There is no more certainty of the mean of four observers being right than if we had one, and that one was changed from year to year. But there is more safety in taking a mean. We have, however, here the mean of four observers with a constant personality on one side, and then in the course of years four different observers giving a mean on the other side. The moral of this is, I think, that we want to get some standard of reference. We have got now to such accuracy in the solar tables that the present position is that we have to use them to find out the personality of our observers, which is a sort of putting the cart before the horse. At Greenwich we have a personal equation machine, and I hope we shall be able to get that to work, because this matter of personality in observations of the Sun has troubled us for some time, and I hope we shall be able to use this to get an absolute standard so that we may connect the observers in long intervals of years. The difficulty of this investigation has been to connect the earlier observers with the later ones. The only link between them was Mr. Criswick, and the weak point in the whole thing is that we have to assume that he has not changed his personality. If the one observer who forms a connecting-link between two periods changes his habit we have a difficulty, but by referring to some invariable standard, such as is given by the personal equation machine, we get over that trouble.

Dr. Roberts showed a photograph of Gale's Comet, and pointed out that it showed a diffused nucleus and not a stellar one.

Prof. Turner. There is a paper here from the Royal Observatory, Greenwich, giving observations of position of the comet; a note by the observer on May 7 states that he saw the nucleus as stellar and slightly elongated.

Mr. Crommelin. On all nights that the comet has been seen at Greenwich after dark the nucleus has appeared stellar. These observations have been made with a power of 55 on the Sheepshanks equatorial.

The following papers were announced:—

Joseph Gledhill. "Observations of Phenomena of Jupiter's Satellites at Bermerside Observatory, in the years 1892 and 1893."

Joseph Gledhill. "Note on the Red Spot on Jupiter."

Isaac Roberts. "Photograph of the Nebula M 78, and H IV. 76 Orionis."

Isaac Roberts. "Photograph of the Nebula M 74 Piscium."

Prof. Simon Newcomb. "Two Questions on Mr. Stone's proposed Correction to the Measure of Time."

F. W. Dyson and W. G. Thackeray. "The Effect of Personality in Observations of the Sun's Right Ascension on the Determination of the Position of the Ecliptic."

Prof. H. H. Turner. "On some possible Improvements in Meridian and Extra-meridian Observing."

Royal Observatory, Greenwich. "Observations of Gale's Comet (*b* 1894)."

Royal Observatory, Greenwich. "Observations of the Conjunction of Uranus and α Libræ made with the Transit Circle."

J. L. E. Dreyer. "Note on the Solar Eclipse of 1858."

J. L. E. Dreyer. "Note on the Proper Motion of the Star LL 38239."

E. J. Stone. "Reply to Prof. Newcomb's two questions on the proposed Correction to the Measure of Time."

Rev. T. E. Espin. "A new Variable Star of Type IV."

Hermann Struve. "On the Dimensions of Saturn's Disc."

The following gentlemen were elected Fellows of the Society:—

Major Archibald Drummond, Guards' Club, Pall Mall, S.W. (proposed by Lord Crawford); *S. Maitland Baird Gemmill,* c/o W. L. Wilson, 254 St. George's Road, Glasgow (proposed by Lord Kelvin); *Samuel A. Saunder,* M.A., Mathematical Master at Wellington College (proposed by H. F. Newall).

The following gentlemen were elected Associates of the Society:—

H. Poincaré, Paris; *A. A. Michelson,* Cleveland, U.S.

The following Candidates were proposed for election as Fellows of the Society:—

Rev. Saml. Robert Browne, M.A., LL.D., Mathematical Master, Bristol Grammar School, Camelot, St. John's Road, Clifton; *Rev. F. J. Eld,* M.A., Whiteladies, Worcester; *Henry Owen,* F.R.G.S., F.R.M.S., Royal Thames Yacht Club, 7 Albemarle Street, W.; *George C. Pulsford,* Head Master, Royal Hospital School, Greenwich, S.E.; *W. Rickmer Rickmers,* Schwarzspanierstrasse 18, Vienna; *William Stewart Stewart,* Levern House, Barrhead, Scotland.

BRITISH ASTRONOMICAL ASSOCIATION.

The sixth ordinary Meeting of the British Astronomical Association for the current Session was held at University College, Gower Street, on the 25th ult., Dr. A. M. W. Downing, M.A., F.R.A.S., presiding.

Mr. P. F. Duke, F.R.A.S. (one of the Secretaries), read the minutes of the previous meeting, the names of ten candidates for membership and six new members elected by the Council.

Miss Everett read letters from Prof. H. Mohn (Director of the Meteorological Institute of Christiania) and Prof. Woeikof (Imperial University, St. Petersburg) in response to enquiries on behalf of the Solar Eclipse Committee. The letters contained much useful information as to the probable weather and atmospheric conditions at the various proposed stations.

Mr. E. W. Maunder remarked that Prof. Woeikof's communication was not encouraging as regards Nova Zembla, and seemed to point to the desirability of not going further than Vadsö. Mr. Ledger had urged the selection of a station on the west coast of Norway, near Bodö, but the letters read were not encouraging in that direction either, and on the whole Vadsö seemed the most promising locality.

The President remarked that at the station suggested by Mr. Ledger (the island of Tré near Bodö) the Sun would only have an altitude of 5° at totality, so that it was out of the question however clear the sky might be. The east coast of Siberia and the northern island of Japan offered special advantages, but he feared that was too long a journey for English observers.

Mr. Edwin Holmes read a paper "Upon Mechanical Means of Converting Hour-angle and Declination into Azimuth and Altitudes, and Conversely." Mr. Holmes referred to several devices for this object that had been described in the 'English Mechanic' in 1892 and 1893, but he thought that they either required a multitude of diagrams or were too expensive. He claimed for his own design sufficient accuracy to bring the required object into the field of the finder.

Capt. W. Noble described an ingenious apparatus for the solution of spherical triangles exhibited some eighteen years ago by Mr. Penrose at Burlington House.

Miss Everett read a paper by Rev. W. R. Waugh, F.R.A.S., on "Markings on the Equatorial Zone of Jupiter," and *Mr. E. W. Maunder* read a note by Miss E. Brown on "A peculiar Feature of the Large Sun-spot of Feb. 1894."

Mr. Holmes then read a paper on "Astronomical Drawing," in which he pointed out the curious and sometimes extraordinary discrepancies in the drawings of the same object by different observers, and he urged the simultaneous drawing of the same object by as many members as possible, so as to enable individual idiosyncrasies to be eliminated. The paper was followed by a lengthy discussion, in which Capt. Noble, Mr. E. W. Maunder, Mr. G. M. Seabroke, and Mr. Hardy took part.

Miss Everett read an interim report of the Lunar Section by the Director (Mr. T. Gwyn Elger, F.R.A.S.), after which, *Mr. E. W. Maunder* exhibited and explained a number of lantern-slides of portions of the Milky Way and other stellar fields. "Some Notes on Mira Ceti," by Lt.-Col. E. E. Markwick, F.R.A.S., were read, and the President in concluding reminded the meeting that two comets, both discovered by members of the Association—one by Mr. Denning, and the other by Mr. Gale,—were now observable. He hoped that members would pay attention to both these comets.

The Meeting adjourned at 7 P.M.

ROYAL METEOROLOGICAL SOCIETY.

The monthly meeting of this Society was held on Wednesday evening, May 16th, at the Institution of Civil Engineers, Westminster; Mr. R. Inwards, F.R.A.S., President, in the chair.

Mr. W. Ellis, F.R.S., read a paper "On the relative Frequency of different Velocities of Wind," in which he discussed the anemometer records of the Greenwich Observatory for the five years 1888–1892, with the view of ascertaining the number of hours during which the wind blew with each of the different hourly velocities experienced during the period. The results of this discussion show that the wind blew for the greatest number of hours with the velocities of 10 and 11 miles.

Mr. W. Marriott, F.R.Met.Soc., gave an account of a series of observations on the "Audibility of 'Big Ben' at West Norwood," which he had carried on for a period of five years. The Clock Tower at Westminster is 5½ miles distant from the point of observation in a north-by-west direction. The large bell "Big Ben" was designed by Lord Grimthorpe, and was cast in 1858; its weight is about 14 tons. It is 9 ft. 5½ in. in diameter, and 9⅞ in. in thickness, its tone being E. The observations were 976 in number, and were made at the hours 9 A.M. and 9 P.M. The bell could be heard more frequently in the evening than in the morning, and on Sundays it was more frequently audible than on week-days. The direction of the wind most favourable for hearing 'Big Ben' was between west and north. The observations were also discussed in relation to temperature, moisture, cloud, and barometric pressure.

A paper by Mr. A. W. Moore was also read on "Earth Temperatures at Cronkbourne, Isle of Man, 1880–1889."

Fireball of 1894 *April* 22.

In broad daylight, at 7^h 36^m, on Sunday evening, April 22, one of those fine, slow-moving meteors which often appear in the evening hours, and are directed from radiants in the western half of the sky, was seen by many persons. Nearly all the observations come from London and that district, where the fireball descended in a nearly vertical path to the S.E. horizon, varying in its diameter and its light as it fell. Very few of the stars had come out at the time, so that the course of the object could not be very accurately fixed in the absence of suitable sky-marks. Descriptions of its appearance come from Horsham (Sussex), Ramsgate and Gravesend (Kent), Chelmsford (Essex), Knebworth (Herts), Kenley, Redhill, Guildford, Chiddingfold, and Haslemere (Surrey), Warminster (Wilts), London, Bristol, Southampton, and other places, but the meteor was not favourably placed for general observation over the country. Its real path lay over the Strait of Dover, so that observers in the S.E. counties and in the north of France would have the best view of the apparition. Some of the accounts are not sufficiently definite to be useful and a few of the others are not consistent when compared together; it is therefore only feasible to deduce the real path in a roughly approximate manner. Before giving the results, such as they are, it may, however, be interesting to quote from a few of the recorded descriptions :—

Kenley, Surrey.—" On Sunday evening, April 22, at $7^h\ 36^m$, a very large fireball was seen here, and the point of disappearance was unusually well ascertained. This was in azimuth 44° 30′ E. of S. and altitude 5° 45′. The meteor moved rather slowly, and the nucleus was of an intense bluish-white colour surrounded with a yellow or reddish coma; it broke into two pieces before disappearing. The direction of flight was rather uncertain, as only the end part was seen, but it appeared to two other observers to fall vertically down."—J. EVERSHED.

Knebworth, Herts.—April 22, $7^h\ 35^m$. "Large meteor started about halfway between α and β Leonis and moved down in a slightly curved path between Crater and Corvus. Colour vivid green, with a tail of red sparks, which became larger and more numerous near the end, and it finally broke up into a ruddy cluster which could be traced for 2° or 3° further. Diameter appeared about 6′, and far outshone Jupiter, but not as bright as full Moon."—F. J. WARDALE.

Chelmsford, Essex.—April 22, $7^h\ 40^m$. " Meteor much brighter than any planet seen. It was in view 2 or 3 seconds and passed from close to α Leonis to a little short of Corvus. It was of a whitish light and left a brilliant track behind it."—R. W. CHRISTY.

Haslemere, Surrey.—April 22, about $7^h\ 25^m$. " A very fine meteor was seen to traverse the sky from near the zenith to near the horizon in an easterly or south-easterly direction. It threw off sparks like a rocket and was followed by a bright train. No noise was heard after the explosion."—Hon. R. RUSSELL (letter in *Nature*).

Redhill, Surrey.—April 22, $7^h\ 35^m$. " While walking near Redhill a remarkable meteor was seen. Appearing near the meridian, it descended vertically towards the south-western [? eastern] horizon. At first of a brilliant white, it gradually changed to a pale green colour, and finally, when near the earth, it dispersed into fragments, each of a bright red. The duration of the phenomenon was about 4 seconds."—D. W. B. (letter in *Standard*).

Guildford, Surrey.—April 22, $7^h\ 35^m$. " In bright daylight a very large meteor fell in the east of the heavens in direct line to the earth, leaving behind a magnificent train of blue. After travelling to within a very short distance of the earth it broke into three pieces, something like the bursting of a sky-rocket, the lower portion being about the size of a breakfast-cup. The sight was the more remarkable, there being no other star visible in the clear light of day."—ARTHUR ALLEN (letter in *Surrey Times*).

Chiddingfold, Surrey.—April 22, $7^h\ 37^m$. " Observed a grand meteor or fireball. It was almost light at the time, and the phenomenon appeared to last at least five seconds. It commenced with the aspect of a large planet about E.S.E. and some 20° above the horizon. The head then plunged downwards, and vanished at about 5° altitude in S.S.E. The tail formed a splendid curve about 15° in length, and the head increased in size during its flight until it was vastly larger than Venus and Jupiter together, and, in fact, even rivalled the full Moon. It seemed to stand out from the sky, and did not appear to be more than a few miles distant."—A. F. TARBURY (letter in *Symons's Meteorological Magazine*).

Warminster, Wiltshire.—April 22, 7^h 34^m. "I was fortunate enough to witness a splendid fireball. In full daylight and in a sky of the clearest blue the meteor appeared like an immense rocket. The direction seemed to be north-west to south-east, and the large star-shaped body, brilliant as an electric light, slowly descended and disappeared without a sound. It must have been a powerful celestial phenomenon to be seen under the conditions prevailing."—Rev. J. F. WELSH.

Euston Road, London.—April 22, 7^h 35^m. "A large meteorite or fireball observed. It was about 70° above the horizon and travelled downwards towards the eastern horizon near to where the sun rises. It was in view for about 5 seconds. In appearance it was pear-shaped and of a pale green colour, followed by a train of sparks. No stars were visible in the vicinity."—C. PHILLIPS (letter in *English Mechanic*).

Ramsgate.—April 22, about 7^h 20^m. "Very brilliant meteor seen. It was of considerable size, much larger than Venus at her brightest, having the appearance of a very large rocket. Its colour was of a brilliant white at first, afterwards changing to blue and violet. It left a slight trail, which did not last. Duration about 3 seconds. There was not the slightest noise. It appeared to come from the N.W."—DEIMOS (letter in *English Mechanic*).

Bristol.—April 22, about 7^h 30^m. Brilliant fireball observed moving slowly and falling almost vertically in E.S.E., with slight inclination from left to right. A fine object, though daylight very strong at the time. Sky unusually clear, but it was too early for stars. This description was given by an eyewitness.

The real path of the meteor seems to have been observed from a height of about 80 miles above the district of Hastings to a height of about 17 miles near Amiens in France. The length of its luminous course was about 120 miles. As to the radiant-point, this is indicated in the region of α Persei. The direction of the meteor's flight was from N.W. to S.E. The average duration from six estimates was 4 seconds, which would give a velocity of 30 miles per second; but this is probably somewhat in excess of the actual speed. An additional observation of satisfactory character would serve to test these results, which are extremely uncertain. It seems, however, desirable to publish some facts concerning the fireball, for its great brilliancy, in spite of the twilight, and the westerly position of its radiant are significant facts entitling it to record, and it is hoped that some further observations may now be forthcoming to enable the real path to be assigned in a reliable manner.

Bristol, 1894, May 11. W. F. Denning.

[A correspondent writing from Hutton, Essex, to the Astronomer Royal gives the colour as brilliant electric blue, and states that it seemed to give off a separate ball of fire when close to the ground. —Eds.]

The Annular Eclipse of 1894 *April* 6.

An annular eclipse of the Sun is not usually of great scientific interest; the following extract from the report of an expedition from St. Xavier's College, Calcutta, to Naraingunge, East Bengal, is given here as a record of the visual appearance of the phenomenon, and also as evidence of interest taken in astronomy in India. It is to be regretted, as we learn from another part of the report, that the whole of the photographic plates were afterwards hopelessly destroyed by an unfortunate accident.

"The solemn moment was now near at hand—Clouds, clouds, thickening clouds on every side, not single but in deep shoals and massive banks, which all seemed to drift in the wrong direction. The prospect was not encouraging. Nothing daunted, if somewhat depressed in mind, the observers stood at their post; the last adjustments were made, and all was ready for work. Nor was it wholly in vain. For, at the last moment, a merciful rent in the heavy clouds allowed us to time the first contact. The photographic department at once set their ingenious and improved apparatus going, and a first plate, with no less than eight solar images, was successfully drawn. Their plan was to take one plate of eight photos every ten minutes, of the 156 that the eclipse was to last. But it soon became apparent that the best course would be to avail themselves for that purpose of every break in the cloudy screen.

"The culminating point was drawing near; but the state of the sky was far from improving. The Sun remained more persistently and heavily veiled than ever, so that we had well nigh given up all hope of catching the least glimpse of that glorious ring, for the sake of which alone we had transferred ourselves to the distant wilderness, with all our belongings, at the cost of so much trouble, inconvenience, and expense. However, as at the first contact, so likewise at this by far the most important phase, were the skies not wholly unkind to the observers. A glimpse we certainly got, but a glimpse only. For, just at the right time, and at the right place, the curtain was drawn, and a most fascinating spectacle disclosed to our entranced sight.

"The vision lasted but three or four seconds, out of the possible ten—just enough for the chronograph to record the exact moment—just enough to allow of our verifying that the ring was complete, encircling the Moon's dark orb symmetrically, although jagged and cut up, so as to offer a serrated appearance—the so-called "Baily's Beads," no doubt—just enough to ascertain that consequently we had succeeded in getting at the calculated point, very near, if not actually on, the very line of centrality,—enough, too, for two or three photos of the annulus to be taken, had not a most untoward and wholly unexpected accident paralysed, at that brief moment, our photographic department.

"Before they were again ready for work, the clouds had closed up once more upon the yet unbroken ring, and when the Sun next re-appeared, he had long passed the annular stage. Some more plates, however, were taken, at lengthening intervals, completing a fine series of fifteen, each exhibiting eight distinct phases: in all, one-hundred-and-twenty graduated solar images, accurately timed, whose value and beauty was further enhanced by the presence on the fiery disc of two fine groups of Sun-spots, while even the light flitting atmospheric vapours that half veiled some of the luminous crescents, variegating and diversifying their aspect, only added a new feature of loveliness to the sun-painted pictures. The last contact, however, as well as the greater portion of the latter half of the eclipse, were totally swamped in the ever deepening sea of invidious clouds.

"The obscuration of the skies and scenery, even at the height of the phenomenon, was hardly as intense and impressive,—owing to the state of the atmosphere—as might have been anticipated, considering that the ring of sun-light was only about 1½ seconds broad (1·66) and that fully 996 parts of the Sun's surface—and these, its most luminous portion—were, during annularity, screened off by the lunar disc. Here and there, however, a blue patch between the clouds would exhibit a dull, dead coloration, intermingled with a tinge of purple, not unlike what is observed in total eclipses, a few minutes before totality.—The thermometric and photometric observations, too, in spite of all perturbing factors, exhibit a well-marked, though somewhat irregular curve, falling from 91° to 81°, and then rapidly rising, after the central phase, to 96°. In the downward period may be traced a sort of struggle between the rapidly increasing power of the solar rays, as he soared higher and higher above the horizon, and the yet more rapidly decreasing number of these rays, as the Moon's stealthy advancing orb cut them off. Whereas, in the latter, or rising period, both causes combined to accelerate, despite cloud and mist, the progressive rise of the thermometer."

Selenographical Notes.

THE CICHUS MOUNTAIN-ARM AND THE CLEFTS IN ITS VICINITY.—Some years ago I drew attention in the 'Observatory' to certain details in connection with this interesting formation, some of which had not apparently been previously noted and others which were incorrectly represented in the maps. Since then many opportunities have been afforded for observing the region, one of the most favourable occurring on March 16, this year, between 8.30 and 9.45, the E. long. of the morning terminator being about 28°, and the interior of Cichus rather less than half filled with shadow. A short distance on the N. of the ring-plain a great rectilineal fissure traverses the mountain-arm from N.W. to S.E., and in its course it has clearly interfered with the N. border of the large crater marked *i* in Neison's Map xiv., which formation must consequently be of anterior date. On October 14, 1888, I fancied that a cleft extended across the plain west of this gorge towards the prominent crater Cichus *e*, an observation which has been subsequently confirmed. On March 16 it was traced from the N.E. flank of this object to the W. end of the fissure, and also from its E. end over the dark plain up to the W. wall of Capuanus, passing in its course a little S. of a small but obvious crater, omitted in the maps. On the same evening a very delicate cleft was recorded in the hilly region S. of Cichus and Capuanus. It appears to commence on the W. at Cichus B, a bright crater standing on the S. edge of a bay or inflection in the coast-line of the M. Nubium, W. of the mountain-arm, and trends towards the S.E., passing on the south side of the conspicuous ring, Cichus *a*, and then, after traversing a mountain-plateau, it runs S. of the complicated group of irregular formations south-west of Capuanus, to a point some distance on the southern side of the small ring-plain *e*, associated with this formation, beyond which I could trace it no further. Throughout the whole of its course it is a difficult object and does not appear to be perfectly continuous, as two or three short gaps were noted between Cichus B and *a*. On this section of the cleft several very minute craters were also observed. I can find no record of it either in Schmidt's 'Rillen' or in any map. A power of 384 was used on a 8½-in. Calver reflector, but it was seen with 250, and held steadily at times of best definition. I believe that another and still more delicate cleft exists a few miles S. of this and runs nearly parallel to it; at any rate, there is a number of short fissures of extreme tenuity in this position, arranged in a line trending towards the S.E., which probably represents the coarser parts of a fine rill.

The detail on the Mare Nubium immediately under the W. flank of the Cichus mountain-arm is very noteworthy, and would appear to be in part the result of land-slips from the cliff above. On the north-east side of Cichus *c* (the crater on the eastern wall of Cichus) is another bright little crater standing on the Mare about 10 miles distant, the intervening space being occupied by a row of much smaller depressions. Schmidt is the only selenographer who shows these objects, but they were well seen on the night of March 17, when they were clear from the broad prominent shadow of the E. wall of Cichus, by which they are hidden when the formation is observed under its most favourable phase. Has Cichus a central mountain? Schmidt draws a small mound near the centre, two ridges on the eastern side of the floor, concentric with the foot of the slope, and a minute object on the south-western quarter of the interior. Neison shows only a mound on the east. On November 8, 1875, at 8^h 30^m, Mr. D. Simms, C.E., of Thurso, Canada, observed with a 4½ reflector three prominent little hills, forming the apices of a triangle, casting pronounced shadows on the floor. His observation was made under morning illumination, when the interior was nearly fully illuminated (Eng. Mec. vol. xxii. p. 298). I have often endeavoured, but without success, to confirm this observation, though a central object nearly in the position of Schmidt's mound and other markings have been noted.

Beaumont House, Shakespeare Road,
Bedford, 1894, May 19.

Thos. Gwyn Elger.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Ancient Greek Opinions on the Form of the Earth.

Gentlemen,—

In Prof. Lockyer's recent work entitled "The Dawn of Astronomy" he states (p. 8) that Anaximander taught that the Earth's shape was that of a cylinder, and that Plato held it to be a cube. With regard to the latter, although it is very difficult to feel sure what was Plato's view, as set forth in the 'Timæus,' respecting the rotation of the Earth (Aristotle considered that he believed in it, and Grote accepted this, but we may fairly subscribe to Jowett's conclusion, "that there is nearly as much to be said on the one side of the question as the other"), it is evident from several passages in his writings that he held its shape to be that of a sphere, and he puts the same view into the mouth of Socrates in the 'Phædo' (c. 58). But as regards Anaximander, only a few fragments of what he wrote are extant, so that we are dependent for our knowledge of his views upon the testimony of later writers, and particularly of Diogenes Laertius, who tells us that he taught, amongst other things: *μέσην τε τὴν γῆν κεῖσθαι, κέντρου τάξιν ἐπέχουσαν, οὖσαν σφαιροειδῆ*,—which clearly ascribes a spherical figure to the Earth; a doctrine probably first taught amongst the Greeks by Thales.

Yours faithfully,

Blackheath, 1894, May 18.

W. T. Lynn.

OBSERVATORIES.

Natal.—Mr. E. Nevill's Report for the year 1892 July 1 to 1893 July 1. The staff is composed of three ladies. The chief instruments are an eight-inch Grubb refractor, a three-inch transit, and a magnetic transit recently purchased. "The principal series of observations is the comparison of the declinations deduced from observations made at the observatories in the N. and S. hemispheres, by a comparison, by Talcott's method, of the zenith distances of northern stars and southern circumpolar stars." During the recent opposition of Mars "38 sets of meridian and 62 sets of extra-meridian observations were obtained. The whole series are completely reduced and tabulated, ready for the final discussion for obtaining the value of the Solar parallax as soon as the meridian observations made in the N. hemisphere are received. It is noteworthy, as showing the necessity of having two South-African Observatories, and the advantage of having them placed on opposite coasts, that whereas, at the Royal Observatory, Capetown, out of 43 observations made during July, August, and September, only 13 were made obtained before, whilst no less than 29 were obtained after, opposition on Aug. 3; at Natal the proportion was just reversed, no less than 24 out of 38 observations being obtained before opposition. The two sets supplement each other." The following note, or a variation of it, appears annually:—"A great deal of work has now accumulated at the Observatory, awaiting printing and publishing, including a catalogue of R.A.'s of nearly 700 zodiacal stars liable to occultation by the Moon, and a detailed investigation of the latitude of the Observatory, founded on nearly 1100 pairs of observations of zenith stars. It would be well to have these published without delay, as a volume of Natal observations." One other extract—"At present the Equatorial and Transit instruments are practically in the same room, and it is impossible to use both instruments at the same time." A considerable number of observations of magnetic variation were made during the year, and they tend to show that the correction commonly adopted in Natal is much too large. The mean values are for

June....	24°	54'·0 W.
July....	25	1·5 W.
August..	25	9·4 W.

Mauritius.—The Annual Report of Mr. Meldrum for 1892, which has just reached us, gives in the usual form the meteorological mean results for the year, and in most cases the similar average values from the years for 1875–92 for comparison. Since April 1892, besides those heretofore in use, readings of thermometers in a Stevenson's screen at a height of 6½ feet from the ground, and in a similar screen at a height of about 2½ feet from the ground, have been taken. The mean results are given. The Report contains an interesting account of a cyclone which passed over the island on April 29, and of the precautions taken by the Observatory authorities to warn the residents. It appears that this was rather unexpected, as cyclones do not usually visit Mauritius so late in the year, April 12 being the hitherto latest recorded date, and there is no previous record of a cyclone having come from the N.W. as this did. The barometer was as high as 30·06 on the 24th, and fell to 27·96 at 3 P.M. on the 29th, the last inch of the fall being accomplished in 3 hours. At the Observatory the anemograph suffered considerable damage, one cup being blown away and another crushed flat; the vane-fans were so damaged that the instrument would not act after 3.45 P.M. The usual observations of magnetic elements were made during the year, the annual mean values being

Declination	10° 5′ 8″·7 W.
Dip..............	54 48·20 S.
Horizontal Force ..	5·2058 F.G.S.
Vertical „ ..	9·0316 F.G.S.

An electrometer and a Sir W. Thomson's waterdropping collector have been added to the outfit of the Observatory.

578 photographs of the Sun have been taken on 339 days, of which 303 were forwarded to the Solar Physics Committee for measurement.

It is distressing to read that the death-rate of the colony in 1892 was considerably in excess of that in 1891, and that Mr. Meldrum considers that the rate is steadily on the increase. This is derived from figures which except the deaths (1232 in number) due to the hurricane referred to above.

THE KEW OBSERVATORY.—The Annual Report of the Kew Committee for the year 1893 has been just issued. From it we learn that the Kew Committee have been registered during the past year under the Companies' Acts 1862 and 1867 as the "*Incorporated Kew Committee of the Royal Society*" for the following (among other) objects, as stated in the memorandum of Association, viz.:—(1) "the administration under the direction of the Royal Society of the Gassiot Trust Fund for maintaining the Kew Observatory and carrying on the magnetic, meteorological, and other physical observations there," and (2) "the maintenance and the management of an Institution for the supply, examination, and testing of instruments for scientific and other purposes, and the investigation and application of methods of measurement and observation."

The death of the late Superintendent of the Observatory, Mr. G. M. Whipple, B.Sc., is adverted to in sympathetic terms, and the appointment of his successor, Mr. Charles Chree, M.A., Fellow of King's College, Cambridge, is duly noted. The work of the Observatory is briefly reviewed. The magnetical, meteorological, and solar observations have been carried out on the same general plan as in former years. A slight decrease is shown in the number of instruments tested during the year; but a very large increase has taken place in the number of watches submitted for trial, viz., 1521 as compared with 1044 in the preceding year. A new departure has been made in the rating of marine chronometers on the Greenwich system, and a satisfactory commencement has been made with 30 chronometers for the Italian Government, which have been subjected to a severe test. Three Appendices to the Report give respectively, I. Results of the Magnetical Observations; II. Meteorological Results; and III. Results of Watch Trials.

PUBLICATIONS.

THE GERMAN HELIOMETER OBSERVATIONS OF THE TRANSITS OF VENUS, 1874 & 1882 *.—Dr. Auwers is to be congratulated on the completion of another stage of his work on the Transits of Venus. He has reduced and published the heliometer observations, and finds a parallax of $8''\cdot8796 \pm 0''\cdot0216$, as the most probable result from the two transits. The final reductions fill an imposing quarto volume (No. V. of the series) of some 800 pages, closely printed, and obviously represent an immense amount of labour. They, in fact, represent nearly 3 years' work on the part of the distinguished editor, his assistant Dr. Battermann, and others, from the autumn of 1890 to the middle of 1893. After publishing Vols. IV., III., and II. of the series respectively in 1887, 1888, and 1889, Dr. Auwers's attention was temporarily called to other matters, notably the heliometer observations of Iris, Victoria, and Sappho at the Cape, in which he personally took a part. But in 1890 he was enabled to proceed with the reduction and final discussion of the material collected in the aforesaid Volumes IV., III., and II., which respectively summarize:—

IV. Heliometer work preparatory to the expeditions and for testing of the instruments to be used.

III. Observations made in 1882 (both heliometric and others).

II. Observations made in 1874 (ditto).

The first 15 chapters of the present volume V. (about three quarters of the volume) deal with the determination of the instrumental constants—division errors, screw errors, temperature corrections, focus zero, scale value from stars, Sun's diameter as measured with the heliometers, &c. The most interesting chapters in the book to the general reader are perhaps Chapter XII., in which the meridian places found at a large number of observatories for the stars used in determining scale value are compared and discussed; and Chapter XV., which deals with the Sun's diameter.

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* Die Venus-Durchgange, 1874 und 1882; Deutsche Beobachtungen. Fünfter Band: Bearbeitung und Ergebnisse. Erster Abschnitt: die Heliometerbeobachtungen. Berlin, 1893.

The former chapter is of a permanent value independent of the special research, furnishing as it does very accurate positions and proper motions of several stars, and a comparison between the systematic errors of various observatories and catalogues.

In combining the results one cannot help remarking the importance attached to the accordance of observations at the same observatory *inter se*, which is rather characteristic of German work, and which in England would perhaps give way to a suspicion that such accordance was an indication of systematic error; but, after all, so long as observations are treated on some fairly reasonable system, the particular system chosen matters little.

The results of measures of the solar diameter were summarized by Dr. Auwers in a paper in Ast. Nach. 3068, and have already been referred to ('Observatory,' No. 184, p. 66). The mean result is $1919''\cdot3$, which is much smaller than that at present adopted in the various ephemerides (the N. A. uses $1923''\cdot6$); and in the 'Berliner Jahrbuch' for 1895 the adopted value will be changed from $1922''\cdot4$ to $1919''\cdot3$. The diameters are discussed for possible ellipticity of the Sun's disk, and the polar diameter is found to exceed the equatorial by $+0''\cdot032 \pm 0''\cdot023$,—showing that the disk is sensibly circular.

Mr. Chandler's second paper on Pond's double altitude observations appears in the 'Astronomical Journal,' No. 315. It will be remembered that the observational data required for the solution of Mr. Chandler's formulæ is a series of differences $(\delta-\delta_0)$ of observed declinations from some mean value of the declination δ_0, which is free from the effect of latitude variation. If, as was the case with Pond's, the observations of a star have not been uniformly distributed during a period, a simple mean will not be sufficient to give this value δ_0; and an ingenious plan has been adopted to meet the difficulty. Polaris and α Cygni had been observed so continuously as to allow of a simple mean being taken to obtain a mean value; and since the differences of simultaneously observed declination of any two stars must be free from latitude variation, by taking the difference of observed declination of a star from the simultaneously observed declination of one of these two stars, it was possible to get a value of $\delta-\delta_0$ for each observation free from latitude variation. These differences being arranged chronologically and divided into groups embracing ten- or twelve-day periods, the means of the groups were used to get a first approximate result, which pointed to 428·6 days as the mean length of the period; and this first result being used to correct the observations for the effect of latitude variation, a second approximation was made from the corrected values of $\delta-\delta_0$, from which resulted the following numerical values of Mr. Chandler's equation No. 24:—

$$\phi-\phi_0 = -0''\cdot126 \cos(t-2{,}389{,}520\cdot7)\,0^\circ\cdot84 \\ -0''\cdot173 \cos(\odot-14^\circ\cdot9),$$

t being expressed in Julian days.

The observed results, corrected as above stated, are laid down in a diagram, together with the corresponding values as computed by help of the above formula, and the agreement of the two curves is remarkably striking. Mr. Chandler says:—"The epicyclical character required by the announced law of the latitude variation appears thus to be finely illustrated by Pond's observations," and "this series of Pond is the only one in astronomical annals which, taken alone, illustrates in a satisfactory way the existence of the seven-year cycle in the range of the latitude variation."

A point which might cause doubt as to the accuracy of these conclusions is the effect of the neglected error of runs. Airy found evidence that in both of Pond's instruments this error was subject to a seasonal variation, which has also been found in other instruments. Mr. Chandler has made an investigation of this point, with a satisfactory result he considers, by taking observations having large runs and small runs respectively, and determined constants from each set; the agreement of the results leads him to think that any vitiating influence from this source need not be feared.

SUGGESTIONS REGARDING THE APPLICATION OF THE PHOTOCHRONOGRAPH (Georgetown College Observatory).—From the Introduction we gather that the photochronograph was originally devised for photographic observation of meridian transits, but that it can be adapted to prime vertical transits, or to transits in any vertical. The form suggested is "a shutter, made of a light piece of metal, out of which are cut parallel openings of equal width with the strips of metal left between them. This shutter is moved backwards and forwards across the field of view and near the focal plane, perpendicularly to both the optical axis and the length of the openings, by means of an electro-magnet."

With a clock sending signals one second in duration the action would be as follows:—When the circuit was open the images formed in the opening of the shutter will be impressed on the sensitive plate. When the circuit is closed the shutter is drawn on one side, and consequently the parts of the plate exposed before are now covered, and *vice versâ*. Thus with the alternate motion of the shutter the whole trail is broken up by short dashes, separated by equal intervals. A suitable omission of signals permits the identification of any dash.

The necessary wires for measurement of the photographs are impressed on the plates by throwing a light on the object-glass.

The observation takes less time than in the visual method. The same form is suitable to the altazimuth.

Then follows a chapter on the use of the instrument in the determination of absolute personal equation, with a short history of the various methods which have been used for the purpose.

The Photochronograph applied to measures of Double Stars and Planets.—The pamphlet is really a continuation of the above, the whole series being evidently intended for binding in one volume. From this we learn that preliminary experiments were made in 1891, on ζ Ursæ Majoris, and their success induced a further application, and the results of measures of 15 pairs are given, as well as the conjunction of Saturn and γ Virginis in 1893, and some phenomena of Jupiter's Satellites.

The telescope used was a 12-inch refractor, with a third lens of 12-inch aperture acting as a photographic corrector. The telescope being clamped in R.A., the star in an ordinary way would make a trail on the photographic plate; but by means of the shutter alternate trails and blanks are formed, the scale of the photograph being obtained by omitting an exposure at certain intervals.

As regards the result of the application to double stars, we are bound to confess that the labour involved is out of all proportion to the results obtained, which is indeed only what might be expected. To show this we cannot do better than quote freely from the introduction:—"The first thing to start with was a *suitable working-list of double stars.* The difficulties of this selection depend on various elements, such as the aperture and focal length, the amount of absorption of light by the three lenses, and their more or less perfect correction for actinic rays, the colours, photographic magnitudes, and distances of the companions, the linear velocities of their images on the sensitive plate, the time of exposure, the sensitiveness of the plates, and the transparency of the atmosphere at any given time...... the only practical way of making a working-list for this method was that of actual trial. The result of these experiments, carried on at intervals during a year, is the enunciation of the following general principles, which serve as guides for the profitable working of this equatorial in conjunction with the photochronograph:—

"(*a*) Stars of 6th visual mag., and distances 3 seconds of arc, as a rule, limit the production of measurable images.

"(*b*) The amount of exposure must be studied for each particular star, the variation being from $\frac{1}{10}$th sec. to a second. A fifth mag. usually requires a second, but if the components are only 3″ apart, the images overlap. Equatorial stars give elongated images, and it is therefore easier to obtain good pictures of double stars near the pole than near the equator.

"(*c*) The components should not differ more than two magnitudes.

"(*d*) Want of transparency in the air, even if directly undetectable, usually exerts a great influence on the actinic power of a star. Partly owing to this cause of uncertainty 6 or 8 plates are always exposed for any given set of conditions."

These deductions are old friends, or rather enemies, and we can only wonder at and admire the patience displayed in giving them opportunities to assert themselves. Even when one has a certain command over the exposure, (*d*) is to be feared. Instead of giving equal exposures along the trail, it seems to us outsiders that varying exposures would prevent a barren plate. But, apart from all this, we have as the result of one year's work with a 12-inch a set of measures of 15 pairs *, none of which are under 3″, twelve are between 3″ and 15″, and the others 23″, 30″, and 208″ respectively. When we bear in mind that besides the actual exposure and developing of these 663 photographs taken during 40 nights, some 50,000 micrometer settings were made in the measurement, we naturally look for some superior results. In the table below we give some of these compared with those made with a 12¾-inch by a novice, and some with a 9-inch, about the same time:—

Photochronograph.					Direct Micrometer.			
Star.	Plates taken.	Micrometer settings.	Angle.	Dist.	Angle.	Dist.	No. of nights.	Instrument.
			°	″	°	″		inch.
α Geminorum ..	9	700	223·0	5·63	229·6	5·67	4	12¾
					228·8	5·28	2	9
γ Leonis.........	13	1000	115·0	3·53	115·0	3·73	4	12¾
					116·9	3·68	2	9
γ Virginis	5	400	149·0	5·56	151·7	5·86	2	12¾
					153·0	5·49	2	9
ζ Aquarii	3	200	323·7	3·06	321·6	3·39	2	9
					322·9	3·26	2	6

Now that the unsuitableness for double-star work of the photochronograph has been shown, it is hoped that so fine an instrument will be devoted to direct measures.

OBSERVATIONS ASTRONOMIQUES FAITES À ABASTOUMAN.—We have had occasion before to express our approval of Professor Glasenapp's endeavours to secure observations of southern double stars, and it is with lively satisfaction we receive the results of a second expedition. It will be remembered that Professor Glasenapp on the last occasion worked at Hoursouf with a six-inch refractor. In 1891 the University Observatory of St. Petersburg acquired a 9½-inch and no time was lost in putting it to good use. "This time our attention was attracted to Abastouman, a place healthy and picturesquely situated and much frequented by the rich families of the Caucasus. Surrounded by mountains clothed by forests and situated at a height of 5300 feet above sea-level, Abastouman is distinguished for a remarkably pure atmosphere, and in winter the star-images are perfect." Work extended over the period 1892 August to 1893 May. The first thing was to determine the observatory constants, which are

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* Two nights' ordinary work with this size instrument.

Latitude 41° 45′ 42″ N.
Longitude 2^{h} 51^{m} $19^{s}\cdot5$ E.
Height 1393 metres.

The height was determined by barometer.

The double-star observations are in continuation of those made at Hoursouf, and in all some 1220 observations of 610 pairs were secured. Although Prof. Glasenapp's object was to measure known doubles, he found a few new pairs. The list of stars is a long one, and as the results are published early they are of great use, not only for computation, but for comparison with other measures made about the same period. In addition to the double-star measures, Prof. Glasenapp made measures of the star-cluster H. VIII. 38, which contains Σ 1121; some observations of variables, U Arietis, β Lyræ, μ Aquilæ, and Algol; comet Holmes; Lunar eclipse 1892 Nov. 4; and some occultations. Altogether a fine piece of work in so short a time.

NOTES.

Comet Notes.—Denning's Comet appears to belong to the Jovian family of comets, the following elliptical elements having been deduced by M. Schulhof from observations extending from its discovery up to April 25; the elements are still uncertain, but show some resemblance to those of Grischow's Comet (1743 I.) and Blanpain's Comet (1819 IV.), and the identity of the three comets is possible:—

			Grischow's Comet.	Blanpain's Comet.
T = 1894 Feb. 9·08813 Paris M.T.				
π	130° 22′ 50″·2	1894·0.	95°	69°
☊	85 2 50 ·0		89	79
i	5 27 36 ·2		2	9
ϕ	42 50 47 ·6		46	45
μ	526″·079		..	..
log a ..	0·552637		0·490	0·493
Period	6·745 years		..	..

A pretty close approach to Jupiter in 1889 is indicated by the above elements.

The comet will be exceedingly faint in June, but may still be within reach of large instruments. The following ephemeris is for Paris midnight:—

	h m s	° ′
June 5......	12 26 49	3 48 N.
13......	12 39 1	1 45 N.
21......	12 51 4	0 11 S.

Gale's Comet has been a very conspicuous object during May, and has been visible to the naked eye. A photograph taken at Paris on May 5 showed a double tail 4° long. The following extracts are from a letter from Mr. Gale, dated April 16:—"The comet at time of discovery was bright, with considerable central condensation, and about 10′ in diameter. A very faint straight tail, $1\frac{1}{2}$° long, was noted on the 3rd. This appendage increased in brightness until, on the 12th, it had become very conspicuous, in spite of the moonlight. I was surprised therefore on the 15th to find that the ray-like tail had entirely disappeared, being replaced by a broad diffused extension 15′ in length."

The following elements by Prof. Kreutz, from observations April 11, 13, 28, satisfy well the observed places of the comet during May:

T=1894 April 13·5576 Berlin M.T.

ω	324° 17′ 58″	1894·0.
☊....	206 21 14	
i	87 3 31	
log *q*..	9·992746	

Ephemeris for Berlin Midnight.

	R.A.			N. Decl.			R.A.			N. Decl.	
	h	m	s	°	′		h	m	s	°	′
June 3 ..	11	9	14	39	39	June 27 ..	12	2	16	43	16
7 ..		19	38	40	46	July 1 ..		9	47	43	26
11 ..		29	12	41	36	5 ..		17	7	43	31
15 ..		38	7	42	13	9 ..		24	19	43	34
19 ..		46	31	42	41	13 ..		31	26	43	33
23 ..		54	33	43	1						

Brightness on June 3 $\frac{4}{9}$, on July 13 $\frac{1}{17}$ of that at discovery.

Tempel's second periodic comet (1873 II.) was rediscovered by Mr. Finlay at the Cape on May 8, its position agreeing closely with that predicted by M. Schulhof. The following elements, published by him in Ast. Nach. 3229, must be very nearly correct:—

Epoch 1894 June 4·0 Paris M.T.

M	7° 52′ 20″
π	306 14 51
☊	121 10 5
i	12 44 23
φ..........	33 26 27
μ..........	679″·937
log *a*	0·478359

The following ephemeris for July and August is for Paris midnight:—

	R.A.			N. Decl.			R.A.			N. Decl	
	h	m	s	°	′		h	m	s	°	
July 1....	2	16	48	3	15	July 29....	3	14	34	4	30
9....	2	35	2	3	50	Aug. 6....	3	27	41	4	27
17....	2	51	55	4	14	14....	3	39	4	4	14

The comet at rediscovery was circular, less than 1′ in diameter, about 11th mag., with some central condensation but no tail. It has not been observed since 1878, so the rediscovery is of interest.

A. C. D. C.

Minor Planet Notes.—Permanent numbers have been assigned as follows:—AQ 379, AR 380, AS 381, AT 382, AU 383. All the above were discovered by M. Charlois in January last.

A. C. D. C.

On the Determination of the Principal Term of the Nutation. By Dr. Kurt Laves (Ast. Journ., No. 317).—The inequality known as the lunar equation, which occurs in the apparent motion of the Sun, and which arises from the motion of the Earth and Moon about their centre of gravity, can be advantageously applied to find the Moon's mass, when the value of the Sun's parallax has been determined otherwise. The coefficient of this inequality was found by Le Verrier (corrected slightly) to be 6″·53±0″·03, from a discussion of observations of the Sun extending over 58 years. Dr. Laves, by a discussion of Dr. Gill's heliometer measures of Mars made on Ascension Island in 1877, finds the coefficient to be 6″·53±0″·05. As these observations extended over a few months only, and give so small a probable error, Dr. Laves concludes that great gain in accuracy may be expected in the determination of this coefficient from heliometric observations of planets whose orbits are well known, instead of from meridian observations of the Sun.

Now if β be the constant of lunar solar precession and N the principal term of the nutation, Dr. G. W. Hill (Ast. Journal, No. 289, Vol. xiii.) has found the equations

$$\left.\begin{array}{l} \beta=[3{\cdot}6876097]\dfrac{C-A}{C}+[5{\cdot}9375945]\dfrac{1}{1+\frac{1}{\mu}}\dfrac{C-A}{C} \\ \text{and } N=[5{\cdot}36543218]\dfrac{1}{1+\frac{1}{\mu}}\dfrac{C-A}{C}, \end{array}\right\}$$

where the numbers in brackets denote common logarithms, μ is the mass of the Moon, and C, A the Earth's moments of inertia about its polar axis and its mean equatorial axis.

β and N are both found by observation, and these equations have been generally applied to obtain μ and $\frac{C-A}{C}$. But Dr. Laves considers that by finding μ independently through the lunar equation, the first of these equations may be used to obtain $\frac{C-A}{C}$, and then the second equation may be used to find N. The probable value of the error in the determination of both β and N by observation is ±0″·015. As β is five times as large as N, a considerable increase in the accuracy of the determination of N can be obtained by deriving it in this manner, providing that μ has been found accurately in other ways. Dr. Laves considers that by using the value of μ determined by heliometric observations, it may be possible to obtain the value of N with a probable error of $\pm 0''.006$.

In constructing his Second Catalogue of Variable Stars recently published, Mr. S. C. Chandler "had occasion to examine with some care the photometric observations in Vol. xxiv. of the Harvard College Observatory 'Annals' (Observations with the Meridian Photometer). It soon became manifest that there were numerous incongruities in the observations there given, with the known characteristics of variation of many of the stars as well as with other well-attested series of contemporaneous observations."

The above extract is from Ast. Nach. 3214, where Mr. Chandler gives a list of these incongruities; and he ascribes as the reason for them that they may be due to incorrect identification by the meridian photometer, and in twelve cases out of fifteen he gives the names of the stars which may inadvertently have been observed instead of those catalogued. He says:—"The trouble with this hypothesis is that it would lead to the inference that misidentification prevails on so liberal a scale in the work with the meridian photometers (the above list, which is quite incomplete, shows serious errors in fifteen out of the eighty-six telescopic variables observed) as to deprive the photometric catalogues executed in this manner of any scientific value whatever. This is too grave a conclusion to be lightly adopted. . . . . A strong presumption arises that one chief source of the difficulty lies in the failure to secure a proper control of the collimation of the mirrors of the photometer in the process of observation."

Mr. Chandler then goes on to suggest that there may be similar errors in the Photometric Catalogue of Bright Stars (Vol. xiv. of the Harvard 'Annals'), and gives one instance.

In Ast. Nach. 3229 Prof. Pickering imputes animus as the cause of these criticisms, and says "Animus unfortunately is not unknown in scientific discussion, and may exist, as we believe it exists, if at all, in this case, without the person whom it dominates being aware of its presence." He gives a precise account of the method of observation, showing the precautions taken to prevent misidentification; and while acknowledging that in six out of the twelve instances given Mr. Chandler was right in his conjecture as to the star which had actually been observed, he thinks that the number of detected mistakes is too few on which to base such sweeping charges—moreover, too, as the identification of these variable stars, which were generally faint, was more difficult than ordinary. "It is somewhat as though it should be argued, from a physician's losing twenty per cent. of his cholera patients, that he had been equally unfortunate in his general practice."

Columbian Knowledge Series.—Under this title Prof. D. P. Todd is editing a series of handy little works, of which the first, 'Total Eclipses of the Sun,' by Mrs. Todd, has appeared. It contains a useful historical survey of ancient and mediæval eclipses, with brief sketches (accompanied by numerous illustrations) of the knowledge which has been acquired by the observation of total solar eclipses in modern times, particularly that of 1842 and those which occurred subsequently. Ample illustrations have been chosen from a wide field, and include a collection of drawings of the corona in different eclipses. The third volume of the series (to appear in the course of the summer) will be entitled 'Stars and Telescopes,' the instrumental portion being by Prof. Todd, whilst that on descriptive astronomy generally will be in fact a re-issue, again brought up to date, of our correspondent Mr. Lynn's well-known 'Celestial Motions,' the last English edition of which we had occasion recently to notice.

M. Radau's graphical method of solving spherical triangles, noted in our last number, suggests other convenient ways to the same end. Has anyone already noted that since

$$\begin{gathered}4\cos c = 2\cos(a+b) + 2\cos(a-b) + \cos(a-b+C)\\ + \cos(a-b-C) - \cos(a+b+C) - \cos(a+b-C),\end{gathered}$$

c can be found without logarithms simply by adding or subtracting multiples of cosines? and in a case where it is necessary to compute many zenith-distances from colatitude, North Polar distance, and hour-angle, the expression becomes

$$\begin{gathered}2\cos(p+\lambda) + 2\cos(p-\lambda) + \cos(p+h-\lambda) + \cos(p-h-\lambda)\\ - \cos(p+h+\lambda) - \cos(p-h+\lambda),\end{gathered}$$

where λ is constant; and if a table with triple columns giving $\cos\overline{\theta+\lambda}$ and $\cos\overline{\theta-\lambda}$ to argument θ be formed, the computation could be effected by taking out the numbers corresponding to the three arguments p, $p+h$, $p-h$.

Judging from the number of Sun-spots visible, there is some little reason for thinking that the solar activity which has been so excessive for the last two years is on the wane. Since the commencement of the present year there has been a noticeable falling off in the number of the separate groups visible at any one time upon the disk, nor has there been any single spot of the first magnitude since the disappearance of the one which excited so much popular interest in February last.

Referring to a note on p. 158, a correspondent asks whether there is any definite legal authority for the use of Greenwich Time throughout Great Britain. We are able to say, and the information may be of use to others, that in the Statutes (Definition of

Time) Act 1880, 43 and 44 Vic. Cap. 9, it is enacted that whenever any expression of time occurs in any Act of Parliament, Deed, or any other legal instrument, the time referred to shall, unless it is otherwise specifically stated, be held in the case of Great Britain to be Greenwich mean time, and in the case of Ireland, Dublin mean time.

But Sir James Stephen says, in the Larceny Act, Crim. Law Digest, p. 247, 3rd Sect., on the expression "of the clock":—"It may be worth while to observe that the expression 'nine of the clock,' 'six of the clock,' indicate *mean* as opposed to *solar* time; but a question might arise as to whether they mean local mean time or the mean time commonly observed at any given place. 'London time,' or as it is called railway time, is now very generally observed, and there is a difference of more than 20 minutes between London and Cornwall. Local mean time is the natural meaning." In the case referred to at the end of our note on p. 158, a defendant who arrived at a court at the local (Carlisle) time appointed by the Court to sit, but found that the court had met by Greenwich time and had decided the case against him, was granted a new trial.

The following are Dr. Gill's general suggestions referred to by Prof. Turner at the Astronomical Society's meeting and form the concluding paragraph of his paper. We are indebted to the Secretaries of the Society for an advance copy of this:—

1. Whether, in the opinion of astronomers generally, steps should be taken for a more complete and harmonious organization and partition of the astronomical work of the world from the year 1900?

2. Are astronomers prepared to enter upon a preliminary study, discussion, and experiment on the practical methods by which the art of observation may be raised to a higher level of accuracy, and its results be derived and published in a more systematic and homogeneous system?

3. If these questions are answered in the affirmative, would it be desirable to hold an International Astronomical Congress, say in 1896, to discuss and make the necessary preliminary arrangements, and then let the definitive programme and partition of work be made at another general congress to be held in the year 1899?

We have lately received an excerpt from the 'Proceedings of the American Association for the Advancement of Science,' Vol. xlii. (1893), giving Prof. C. L. Doolittle's address before the August meeting of this Association on the Variation of Latitude. This gives a history of the problem, and the methods by which it has been attacked from the time of Ptolemy to the present day. An invaluable pamphlet to anyone wishing to acquaint himself with the latest problem of astronomy.

In the May issue of 'Knowledge' Sir Howard Grubb has an article in which he suggests that, as it is not likely that in the future it will be possible to get disks of optical glass of sufficient size to construct an objective which would equal in light-grasping power such an instrument as Lord Rosse's 6-foot reflector, it would be expedient to endeavour to overcome the difficulties of the mounting which hitherto have militated against the use of reflecting telescopes. He proposes and gives in some detail a plan for floating the greater part of the tube of a large reflector in a huge tank, which he thinks would enable a large reflector to be mounted equatorially with stability sufficient for celestial photography.

Our readers may remember the legal case about the Peters-Borst star catalogue, in which Dr. Peters sued his assistant Mr. Borst for possession of a star catalogue made by the latter in unofficial hours. The original decision in 1889 was given in favour of Dr. Peters, and this was upheld by the Superior Court. We now learn from 'Astronomy and Astro-Physics' for May, that the Court of Appeals hands down a decision reversing that rendered in 1889 by Judge Williams and ordering a new trial.

While neither of the parties claimed that the star catalogue had commercial value, it was shown by the testimony of Professors Hall of Washington and Boss of Albany that the cost of the work was not less than $12,000.

The Report of the Smithsonian Institution for the year 1891 is recently to hand. In the appendix, which consists of memoirs of a general character in different branches of science, either prepared specially or selected from foreign journals and proceedings, Astronomy is well represented by Dr. Huggins's well-known address as President of the British Association, and by three articles by Miss Agnes Clerke—"The Sun's Motion in Space," "Stellar Numbers and Distances," and "A Southern Observatory"—all of which have appeared in English publications.

The result of the investigation into the conduct of the Washington Nautical Almanac Office is published in the form of a letter to Prof Newcomb from the Secretary of the Navy, which completely exonerates him from the charges made against him by Dr. J. Morrison.

Our readers will gather, possibly with regret, from our advertisement pages, that Mr. N. E. Green, whose beautiful planetary drawings are well known, is giving up astronomical work. We understand that domestic reasons compel him to live out of England.

We hear that Mr. Tebbutt, of Windsor, N. S. W., is employing his leisure (which he has elsewhere described as a retirement from astronomical work) in putting up a new observatory for the 8-inch equatorial.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 216. JULY. 1894.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, June 8, 1894.

Capt. W. de W. Abney, C.B., F.R.S., *President*, in the Chair.

Secretaries: Prof. H. H. Turner, M.A., B.Sc., and
E. W. Maunder.

Mr. Maunder read the Minutes of the previous Meeting, which were confirmed.

Mr. Maunder. 80 presents have been received since the date of the last Meeting. Amongst those calling for special mention are a number of pictures made from negatives of the Moon taken at the Lick Observatory, the originals being enlarged and retouched by Dr. L. Weinek; a series of original negatives of Jupiter from the Lick Observatory; and two fine photographs of Gale's Comet taken at the Sydney Observatory.

A vote of thanks was accorded to the donors of the presents.

Prof. Turner read a paper by *Mr. W. F. Denning* on "Comet-seeking." The idea had sometimes occurred to the writer of the paper that it would be very interesting to learn from habitual and successful observers in this field what was the average number of hours expended in seeking for a comet. It was questionable whether the chief living finders had ever recorded data necessary to afford instruction on this point. His own work at Bristol in that department had not been sufficient to furnish trustworthy data. Five new comets had been discovered in 596 hours of "sweeping," or one in every 119 hours. Mr. Denning alluded to a class of object often seen though not looked for, namely telescopic meteors. 416 meteors had been seen in 466 hours of observation, or nearly one per hour. The point of interest in the paper was that from January to June Mr. Denning had seen in 193 hours 135 meteors, or at the rate of ·7 per hour, and from June to December 281 meteors in 272 hours, an average of one per hour.

Prof. Turner. Two papers have been received on Gale's Comet. One by Mr. Russell, of the Sydney Observatory, in which he calls attention to the remarkable changes in the comet. The chief interest is in the very beautiful photographs which Mr. Russell has sent with the paper. The discovery of the comet was announced on April 4, and on April 5 and following days satisfactory observations were obtained with the equatorial. The tail was exceedingly faint, and only visible for 7 or 8 minutes. [A photograph of the comet taken on the 5th with one hour's exposure, which showed a marked condensation, was exhibited on the screen, the stars in the neighbourhood of the comet naturally appearing as trails, corresponding to the motion of the comet during exposure.]

The President. I should like to call attention to the fact that every tooth of the clockwork is visible in the star trails in the photograph. This is interesting as showing a method of estimating the number of teeth in the trail. It is absolutely a perfect way of showing the equality of spacing and form of the teeth of the driving-wheel. I have examined many trains of wheels by this method.

Sir Robert Ball described the method adopted by Mr. Graham in making a series of observations of Comet Gale at Cambridge with the Northumberland Equatorial. The observations were made with the square-bar micrometer, which Sir Robert Ball described.

Dr. Isaac Roberts. I notice an absence of the stellar nucleus in the last photograph of this comet shown; on a photograph taken at my observatory, in the midst of the dense nebulous head of the comet there appeared a streak which indicated a pretty fairly defined stellar nucleus.

Mr. Ingall. Was not the comet brighter at the time Dr. Roberts took the photograph than it was when it was taken at Sydney? I have seen no tail to it, and I do not know whether a tail has been seen telescopically.

Capt. Noble. I saw a stellar nucleus visually. It seemed to flash up like an excessively minute star, but it had no tail at the time I saw it.

Mr. Crommelin. Mr. Gale writes that a faint tail was visible early in April, which increased in brightness until the 12th, but diminished in length from $1\frac{1}{2}^{\circ}$ to $15'$ between that day and the 15th. There was a tail photographed early in May in Paris 4 degrees long, but no trace of that could be seen visually; but I think that I saw an account in the 'Astronomische Nachrichten' that a German observer had seen it.

Prof. Turner. I am afraid I omitted to bring out this fact—that Mr. Russell's paper is chiefly concerned with these very remarkable changes in the comet. I will read two instances. "On April 24 there was a separate condensation and well-marked narrow tail 2 minutes across"; on the 29th, "weather partially fine, an exposure of 2 hours was obtained; the coma was 15 minutes in diameter and no defined tail. With the equatorial nothing could be seen of it."

Mr. W. H. Maw. I saw the comet on several nights in May and also last Saturday, and I have not been able to distinguish any signs of a tail; the stellar nucleus has been seen, but rather unsteadily. Last Saturday, when the comet was more faint, the stellar nucleus was seen more clearly and was visible in the 2-inch finder.

Dr. Isaac Roberts exhibited on the screen photographs taken with his 20-inch reflector. The first of these showed the nebulæ ♅ V. 42 and ♅ I. 176, 177 Comæ Berenicis, and Dr. Roberts pointed out that a drawing of ♅ V. 42 was given in the Phil. Trans. for 1833, which showed the nebula extending to a fine point at each end and with a dense nebulous centre. Lord Rosse described it as an extraordinary object with a bright star near the centre. In the present photograph the nebula much resembled a mackerel both in form and markings, with no definite stellar nucleus, but with a bright star near the centre touching the northern edge. The image of the other nebula on the plate confirmed Lord Rosse's statement that it was one and not two nebulæ, and the five stars shown in his drawing were in the positions he indicated.

The next photograph showed the nebulæ M. 65, 66 and ♅ V 8 Leonis. Comparing the first of these, M. 65, with a drawing in the Phil. Trans. for 1833, and with a drawing by Lord Rosse in the Phil. Trans. for 1850, the resemblance was not striking. The photograph showed the nebula as a symmetrical ellipse with a well-defined stellar nucleus surrounded by dense nebulosity, in the midst of which was a spiral ring filled with nebulosity; the whole of this was surrounded by two elliptical rings of nebulosity separated by dark spaces, and five star-like condensations of nebulosity were involved in the rings. Dr. Roberts also explained that the nebula ♅ V. 8 Leonis on this photograph did not resemble the drawing of the same object in the Phil. Trans. for 1833, but the description by Lord Rosse from observations made between 1848 and 1866 well represented the greater part of the nebula. The speaker added that the time was approaching, if it had not already arrived, when discussion concerning the development of these gigantic celestial bodies might be profitably undertaken, for reliable evidence showing their form and structure is rapidly accumulating. The classification of the nebulæ into bright, faint, large, and very large was much too indefinite a description of the objects as now shown by photographs. They would require a distinct classification of their forms, structures, brightness, and their spectra.

A third photograph was shown of the cluster ♅ VI. 37 Argûs, which showed a remarkable aggregation of faint stars in the midst of crowded surroundings of similar stars which covered the sky for several degrees.

The President then called on *Mr. E. B. Knobel* to read his paper, "Remarks on Dr. Roberts's Photographs of Star-clusters."

Mr. Knobel. It is with some trepidation that I venture to read this paper, for it requires some audacity on the part of any one to impugn the accuracy of a photograph. In considering the photographs of star-clusters which have been presented to the Society from time to time by Dr. Roberts, I have been struck with the difference between the appearance as seen on the photograph and in the telescope. The great variation of the magnitude of stars in the same field of view, so obvious in visual observations, is not apparent in the photographs. At first I was inclined to consider this anomaly due to the long exposures usually given; but that explanation is hardly borne out by more minute examination. There is an untrue and unnatural uniformity about the magnitudes which required investigation. At the last meeting Dr. Roberts exhibited a photograph of 44 Piscium and its neighbourhood. It was obvious on comparing a drawing that I had made some years ago with the photograph that I had shown a wider range of magnitude than can be seen on the photograph. If one compares photographs of the same field taken by a refractor and by a reflector, the difference to which I call attention is most conspicuous, and the facts cannot be disputed. To obtain further information on this point I have measured the diameters of a fair number of stars in photographs taken respectively by the MM. Henry and by Dr. Roberts.

The appearances in Dr. Roberts's photographs I believe to be seriously inaccurate. It is unfortunate that we possess so little information as to the size of the photographs of star-disks as taken with different telescopes; it seems apparent that there must be a different scale for reflectors and refractors. It will be remarked at once that the order of magnitude is the same in both reflector and refractor photographs, but the scales are different. In the Pleiades, stars from the 7th to 11th magnitude, which in the refractor photographs show a range of area from 25 to 1, in the reflector photographs range from only 4 to 1. In all the reflector photographs it will be seen that there is an *equalization* of the magnitudes, and thus these photographs present to us a very inaccurate portrait of the object.

Mr. H. F. Newall read his paper on the "Formation of Photographic Star-disks." In explanation of a photograph exhibited on the screen Mr. Newall said:—This is an enlargement of the mark made by α Lyræ on an ordinary photographic plate placed near the visual focus of the 25-inch visual refractor at Cambridge. The series of rings which are seen in this mark have been investigated with interesting results. The mark may be described as a circular spectrum, whose red end is at the centre, and whose violet end fades into invisibility at the confines of the mark. The rings are the hydrogen absorption lines in this circular spectrum of α Lyræ. Other photographs were projected on the screen, contrasting images formed on an isochromatic plate and on an ordinary plate, and also those formed on an isochromatic plate exposed behind a dark yellow glass and normally.

The Astronomer Royal. As a preliminary to the discussion of the paper which Mr. Knobel has read, I think we ought to have a statement of the minimum diameter of the disks on each plate measured. The diameter of the smallest disk photographed depends so much upon the mounting of the telescope, the accuracy of the clock-driving, and various circumstances, that if we compare the least disk with the greatest it does not follow that the range of star magnitudes will be the same for plates taken with different telescopes.

Mr. Knobel. That is hardly the point of the paper. The point is, that the photographs do not represent the object as seen by the eye nor by the telescope, and shows that the areas of the disks taken with the refractor are very widely different for different magnitudes, and that this is not the case with photographs taken with the reflector. I was discussing this question with the MM. Henry in Paris, and they confirmed the opinion I expressed.

Mr. Ranyard. The size of a disk depends on the type of spectrum of the star. We should not expect the same law for all stars, nor for all instruments.

Sir Robert Ball. I agree with the spirit of Mr. Ranyard's remarks. I think all we need expect is some law connecting the figures which represent the size of the images with the figures representing the magnitude of the stars. It is perfectly plain that there is such a law. Here is a very simple one:—If we subtract 2 from the figures in the column giving the magnitudes and multiply by the figures representing Dr. Roberts's areas the product is the same all the way down the column.

Mr. Dennis Taylor. I had the honour to read a paper before this Society in Novenber last on the secondary spectrum of the refracting telescope, in which I suggested that the abnormally large star-disks shown in photographs taken by refractors were most probably due to the circles of confusion formed by the aberrant rays of outstanding colours gradually imprinting themselves on the plate; and I consider that the photographs which Mr. Newall has brought before us this evening may be said to fully confirm my theory, if not absolutely to prove it. I agree with Mr. Ranyard, in his criticism of Mr. Knobel's remarks, about the refractor not truly representing the visual appearance of a field of stars. I cannot understand how a photograph taken with an ordinary refractor can be said to represent a field of stars, when by eye-observation the star-disks are all of about the same apparent diameter. If one observes through a six-inch telescope, for instance, the star-disks all appear of about the same angular diameter of approximately 0″·8. When these star-disks come out photographically from 3 to 60 times the diameter which they appear to have with eye-observation, and some even with a diameter of one minute of arc, I fail to see how photographs taken with a common refractor can be said to represent the telescopic view of the stars as seen with the eye. How about double stars 2 or 3 seconds apart? How could such photographs show these as double stars? I think we have had conclusive testimony this evening that we should not expect photographs to give very *conspicuously* accurate scales of magnitudes of stars. It is an open question as to how far we can trust the *areas* of the star-images taken with an ordinary refractor as real measures of the magnitudes or brilliancy of stars. I have always been very sceptical myself.

Dr. Roberts. I have to congratulate our late President, Mr. Knobel, upon the renewed vigour he has shown, and upon having brought us the latest news from Paris. But I think he has not taken sufficient time to consider the subject of his paper in all its bearings; if he has, the Astronomer Royal must feel very uncomfortable, as must also the possessors of those costly and beautiful photographic instruments designed for the international astrographic survey, for if the photographs are of no value it is a very serious matter. However, I think the error lies in the assumption of Mr. Knobel, and if he wants to compare star photo-charts with eye-charts he must first determine the relative photographic magnitude with the eye-magnitude of every star on the plate that he has examined. Of course the eye will see very differently from the photograph, and he must therefore determine a scale from the photograph and not from the eye-estimation; and if he does that he will be able very closely to arrive at identical results in both cases. The Astronomer Royal will tell us they have carefully considered the magnitudes of the stars on the photographic plates and that they do bear a definite relationship to each other and to the time of exposure of the plate. By measuring a particular photograph, and confining the measurements to that plate, a law can be deduced for the magnitudes of the stars on that plate which is more accurate than by eye-observations would be possible. Then the refractor and reflector require different treatment. We are not to assume that the two kinds of instruments have every thing in common. In fact, the whole of the criticisms which Mr. Knobel has brought before us to-night are based upon unsound data, and he must proceed in a very different way before he can attack the accuracy of the photographs. Take the same area of the sky any number of times: and if there are no variables amongst the stars we should get the same relative magnitude values always, and formulæ could be evolved for each plate to reduce those relative values to a reliable system of estimation of magnitudes. I shall be very happy to assist Mr. Knobel if he wants data to work this out in a scientific manner; but I should be very sorry to impose upon the Society and upon the world at large something which is of very little value compared with eye-observations.

Mr. Knobel. I limited my paper entirely to star-magnitudes.

Dr. Roberts. But there are general deductions that all these photographs are of comparatively little value.

Mr. Knobel. No!

Dr. Roberts. However, the relative positions of the stars can be determined with very considerable accuracy, and if the right methods are taken to determine the magnitudes, and they are treated differently from the method in which Mr. Knobel has treated them to-night, he will find greater consistency is given by the photographs than is given by eye-observations.

Mr. Knobel. My point was that photographs of clusters of stars as taken with the reflector are unlike the objects, and I have proved that statement by measurements I have made, and I confirm it by the opinions of others who have no doubt on the subject.

The President. Mr. Newall has anticipated what I intended to bring before the Society myself later. The question of the magnitude of star-disks has occupied my time considerably for the last two or three years, and I have photographs which bear out exactly what Mr. Newall has shown us. The ideal plate and the ideal instrument would give all stars of exactly the same diameter. I will add, further, that magnitudes would be shown by different intensity of light on that ideal photographic plate, and that is the only way that differences of magnitudes ought to be shown, and I congratulate Dr. Roberts on the fact that the areas of his stars are so very much smaller than those taken with a refractor, because it shows his magnitudes are nearer ideal perfection. His instrument being free from secondary spectrum is more nearly perfection than that constructed by the Brothers Henry. One thing Mr. Newall has shown on the screen which I do not think is quite fair; and that is, side by side he has shown the ordinary plate and the isochromatic plate with and without the screen. As a matter of fact the isochromatic plates will require about 30 times the exposure with the dark yellow screen that they will without it. I think he has scarcely done justice to the ordinary plate.

As to the definite relation of star-magnitudes, I think these very experiments show that for every telescope there will have to be a different formula brought to bear. We have had a number of formulæ of photographic star-magnitudes published and they all differ. The idea seems to be that people should get their star-magnitudes exactly by the same formula. When you see how star-disks are made, as Mr. Newall has shown, you will see that is impossible unless a reflector is used. Then the only main factor to deal with is the photographic plate. I hope someone will bring this forward another time, when we shall be able to further discuss Mr. Knobel's ideas.

Mr. Sidney Waters then read his paper, and showed on the screen maps of the northern and southern celestial hemispheres on which were charted the nebulæ and clusters in Dr. Dreyer's Catalogue of 1888.

A paper by *Mr. Bompas*, communicated by *Mr. A. Cowper*

Ranyard, was read, "On the Semi-Annual Variation of Meteors." According to Coulvier Gravier, Schmidt, Denning, and other observers, the number of meteors seen in the second half of the year exceeds by two or three times the number in the first half-year. This variation has hitherto been attributed to the planetary motion of the Earth, upon the same principle by which the horary variation is explained. The observer each night is carried round from evening to morning, from the back of the Earth in her orbital motion to the front, where more meteors are encountered. So in the second half-year the northern hemisphere being in front of the Earth's planetary motion should encounter more meteors than in the first half-year; while in the southern hemisphere the season of frequency should be reversed. It appears, however, that this cause is insufficient to account for the amount of variation observed; and the observations of Dr. Neumayer at the Melbourne Observatory show that the variation is not, in fact, reversed in the southern hemisphere, but follows the same law of an increase in the second half-year. A further explanation common to both hemispheres is therefore required.

It was suggested that the variation may probably be due to the cosmical motion of the solar system, which causes a semi-annual variation in the absolute motion of the Earth. This, if meteors were at rest in space, would cause a contrary variation, more meteors would be encountered in the first half-year, when the Earth's absolute motion is swiftest. But if meteors are assumed to have an average general motion following and overtaking the Sun, the conditions would be reversed, and the larger number of meteors would be encountered in the second half-year, when meeting the Earth, than in the first half-year, when being overtaken by her.

Such an explanation attributes to meteors a cosmical motion and a cosmical origin.

The vast number of meteors, their prevalent direction from longitude 0° to 90°, and the position of Denning's radiants, as corrected by M. Kleiber, were referred to in support of their cosmical character and assumed motion.

The following papers were announced:—

Prof. E. W. Brown. "Note on the Lunar Theory."

W. F. Denning. "The Discovery of Comets."

Isaac Roberts. "Photograph of the Cluster ♅ VI. 37 Argûs."

Isaac Roberts. "Photograph of the Nebula ♅ V. 42 and ♅ I. 176, 177 Comæ Berinicis."

Isaac Roberts. "Photograph of the Nebulæ M 65, 66, and ♅ V. 8 Leonis."

Lieut.-Col. E. E. Markwick. "Note on the Variable Star U Orionis."

John Tebbutt. "Orbit-elements of Comet Gale, 1894.

H. C. Russell. "Observations of Comet Gale, 1894."

Sidney Waters. "On two Distribution Maps of the Nebulæ and Clusters in Dr. Dreyer's Catalogue of 1888."

A. M. W. Downing. "Note on B.A.C. 5255=Brisbane 5525."

Sir R. S. Ball. "Observations of Gale's Comet made at the Cambridge Observatory."

E. B. Knobel. "Remarks on Dr. Roberts's Photographs of Star-clusters."

W. F. Denning. "Motions of Fireballs and Shooting-Stars relative to the Earth."

G. C. Bompas. "On the Semi-Annual Variation of Meteors."

J. E. Gore. "On the Orbit of OΣ 82."

E. J. Stone. "On some Points connected with the Integration of the Differential Equations of the Relative Motions of Material Systems."

E. J. Stone. "Note on the Distribution of the Stars generally used for the Determination of Clock-Error with respect to the Equator."

A. Marth. "Ephemeris of the Satellites of Mars, 1894."

A. Marth. "Ephemeris for Physical Observations of Jupiter, 1894–5."

Prof. H. H. Turner. "Some Measures of Photographs of the Pleiades at the Oxford University Observatory."

H. F. Newall. "On the Formation of Photographic Star-Discs."

Prof. H. H. Turner and W. G. Thackeray. "On the R−D Discordance."

Royal Observatory, Greenwich. "Observations of Gale's Comet (*b* 1894)."

The following gentlemen were elected Fellows of the Society:—

Rev. J. T. W. Claridge, M.A., Tamworth, Staffordshire; *David G. Simpson,* 199 Camberwell Grove, Denmark Hill; *Rev. Ernest H. Smith,* M.A., R.N., H.M.S. 'Tourmaline,' N. America and West Indian Station; *Sir John Benjamin Stone,* The Grange, Erdington, near Birmingham.

The following Candidates were proposed for election as Fellows of the Society:—

Geo. C. Bompas, 121 Westbourne Terrace, Hyde Park, W. (proposed by A. Cowper Ranyard); *Bryan Cookson,* Magdalen College, Oxford (proposed by Prof. H. H. Turner); *Lieut. Basil Taylor,* R.N., H.M.S. 'Blake,' North American Station (proposed by Sir J. Rees).

BRITISH ASTRONOMICAL ASSOCIATION.

The seventh ordinary Meeting of the fourth Session of the British Astronomical Association was held at University College, Gower Street, on Wednesday the 30th May, Dr. A. M. W. Downing, M.A., F.R.A.S., President, in the Chair.

Mr. P. F. Duke, F.R.A.S., read the minutes of the previous meeting, which were confirmed. The election of ten new members by the Council was announced and confirmed, and the names of five candidates for membership were approved and suspended.

Mr. E. W. Maunder, F.R.A.S., read a paper by Miss Brown on "A Visit to the Madrid Observatory." The writer described the transit instrument, the great refractor, and the meteorological instruments, and expressed her regret that, owing to want of funds and the smallness of the staff, none of the observations at Madrid are published.

Miss Everett, M.A., read a note from Herr Leo Brenner on "Critical Changes in the Moon." The paper consisted of an extract from the Journal of the Manora Observatory, Lussinpiccolo (Istria), describing the discovery of several objects near Cassini which did not appear to have been observed before, more particularly a "rill," which was very large and easy to be seen.

Mr. G. F. Chambers, F.R.A.S., said that, speaking from an experience of 30 years with telescopes of all kinds, and considering the differences exhibited by the same object in different instruments and under different powers, he did not believe that there was any valid evidence of any change on the Moon's surface.

Mr. E. W. Maunder, F.R.A.S., exhibited and explained several photographs of portions of the Milky Way and other stellar fields, taken by Mr. Russell, of the Sydney Observatory.

Mr. B. E. Cammell, F.R.A.S., forwarded a drawing of Saturn, accompanied by a note which was read by Mr. E. W. Maunder. The drawing was made with a 12½-inch reflector, by G. Calver, with a power of 350, and showed a great amount of detail. A lantern-slide of the drawing was thrown upon the screen.

Mr. N. E. Green, F.R.A.S. (late Director of the Saturn section), expressed great admiration for the excellence of the drawing, both as to its accuracy and artistic beauty.

Mr. A. J. S. Adams read a note on "A Remarkable Sun-spot" (April 29th), and *Mr. G. J. Newbegin, F.R.A.S.*, exhibited some photographs of Sun-spots and of the Moon, taken with an ordinary achromatic and enlarging lens.

Miss Everett then read a paper which had been received from Dr. J. Keeler, F.R.A.S. (Allegheny Observatory, U.S.A.), on "A Comparison of Drawings and Photographs of Jupiter." The writer said that at the Meeting of the B. A. A. on March 28, Mr. Holmes was reported to have remarked, with reference to certain drawings of Jupiter made by him at the Lick Observatory, "that the belts were not accurately placed, and that a draughtsman who could commit so great an error was not to be trusted in fine detail." Dr. Keeler thought that Mr. Holmes's criticism was not warranted by the facts, and he had since carefully measured a positive copy of an excellent photograph of Jupiter taken with the Lick telescope about the time when the drawings were made, and found that it confirmed his drawings as closely as could reasonably be expected, in fact he was surprised at the close agreement. A table of measurements was appended to the paper.

Mr. Holmes said he had no intention of hurting Prof. Keeler's feelings, and could say nothing with respect to Prof. Keeler's original drawings. He still thought that the reproductions of the drawings shown on the occasion referred to did not exhibit Jupiter as they saw it in the telescope.

Miss Everett next read a paper by the Rev. W. R. Waugh, F.R.A.S., on "The Winds of Jupiter." The writer thought that the belts and spots and other markings on this planet were probably the result of cyclonic action in the Jovian atmosphere rather than anything in the nature of volcanic disturbances.

Papers were also read by the Secretary from Mr. David E. Packer on "The Temporary Stars," by Mr. W. H. S. Monck, F.R.A.S., on "The Relation between the Distances and Spectra of Stars," and from Capt. J. W. Smith on "The Use of Orreries."

The President mentioned that Messrs. Horne and Thornthwaite had sent an equatorial for the inspection of the Members.

The Meeting then adjourned at 7 P.M.

ROYAL METEOROLOGICAL SOCIETY.

THE closing meeting of this Society for the Session was held on Wednesday, June 20th, at the Institution of Civil Engineers, Great George Street, Westminster; Mr. R. Inwards, F.R.A.S., President, in the chair.

Mr. R. H. Scott, F.R.S., read a paper on "Fogs reported with Strong Winds during the 15 years 1876–90 in the British Isles." Out of a total of 135 fogs, 108 were associated with cyclonic, and 27 with anticyclonic conditions. The majority of the fogs occurred with south-westerly winds and with temperatures very close to the maximum for the day.

Mr. R. H. Curtis, F.R.Met.Soc., read a paper on "Some characteristic Features of Gales and Strong Winds." After calling attention to the unsatisfactory state of anemometry, and after describing the "bridled" anemometer at Holyhead, Mr. Curtis stated that the greatest force of an individual gust which he had met with was registered in December 1891, and amounted to a rate of 111 miles per hour, which with the old factor would be equivalent to a rate of about 160 miles per hour. Gusts at a rate from 90 to 100 miles per hour have many times been recorded;

but the usual limit for gusts may be taken to equal about 80 miles per hour, which on the old scale would be equivalent to about 120 miles per hour. Gales and strong winds differ in character very much; and as the result of a prolonged study of their general features as recorded by the bridled anemometer, the author has been able to group them into three general classes. He then described those gales which are essentially squally in character, in which the gusts constitute the main feature of the gale. In an average gale the ordinary gusts follow each other at intervals of about 10 to 20 seconds, while the extreme gusts occur at the rate of about one per minute. Another class of gales are those in which the velocity of the wind is tolerably steady. In the third class are gales which appear to be made up of two series of rapidly succeeding squalls—the one series at a comparatively low rate of velocity, the other at a much higher one, the wind-force shifting rapidly and very frequently from one series to the other. Mr. Curtis also stated that on looking carefully over the anemometer records he had not unfrequently found, very distinctly marked, a prolonged pulsation in the wind-force which recurs again and again with more or less regularity of perhaps twenty minutes or half an hour in some cases, and in others at longer intervals of about an hour more or less.

A New Method in Astronomy.

The methods of exact astronomy have not essentially changed since Flamsteed set up his mural arc at Greenwich in 1689. Everything, it is true, was then in the rough. Instruments hopelessly defective, from the modern point of view, were dealt with on the easy hypothesis of their perfection, while some of the chief elements in the processes of reduction were not so much as thought of. Since then, innumerable and admirable refinements have been introduced by six generations of anxious, active, and ingenious observers; but the same general plan has been adhered to. Nevertheless, the results are not all that could be desired.

Nor are they the best that can be attained. This has been clearly shown by a recent research of Dr. Gill's *, and is clearly recognized by no less an authority than Professor Newcomb †. A reform is, then, inevitable, for there is no stopping short on the endless road towards perfection; and that suggested by Dr. Gill has at any rate the merit of feasibility. The demands made by it upon astronomical energies are, indeed, severe; but they are of a kind which various enterprises, completed, projected, or actually in hand, have well prepared them to meet.

The proposed new method has grown out of special exigencies, and thus possesses what may be called the vitality of a natural development. Originally devised for the observation of Mars at Ascension in 1877, it was applied, in a much more elaborate form, to the similar determinations of the minor planet Victoria made at the Cape in 1889. Its principle is readily explained. Close along the path of a planet near opposition, a number of stars are selected, and linked together, by careful and repeated heliometric measures, into a system of interdependent points. A network of triangles is, in fact, formed on the sphere, just as in a terrestrial survey, the mutual relations of which serve to control each separate determination. The same stars are also observed as well as possible in the ordinary way on the meridian, and by the comparison of their relative places thence computed with those established in the triangulation the very smallest errors can be eliminated. Then, as the planet travels among these rigidly ascertained sky-marks, its situation relative to successive pairs of stars is measured with the heliometer night by night during the favourable period of about a month before and a month after opposition. An extraordinary degree of accuracy can thus be realized. Dr. Gill's observations at Ascension disclosed with the utmost definiteness a minute fictitious inequality in the motion of Mars, "which would never," according to Professor Newcomb, "have been noticed in even the best meridian observations." The tabular error—due to a computational oversight—so unexpectedly corrected, had a coefficient of one third of a second of arc, and was periodical in 13½ days.

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* Monthly Notices, April 1894.

† Astronomical Journal, No. 311.

Yet striking as was the warrant of exactitude furnished by its discovery, a notably closer approach to ideal excellence was achieved twelve years later. The operations on Victoria afforded three remarkable results. First, and primarily, a solar parallax of 8″·800, with a probable error of 0″·006, corresponding roughly to a mean distance from Earth to Sun of 92,800,000 miles, uncertain to the extent either way of no more than 6000 miles! This triumphant solution of a great problem was associated with the reduction, by one-sixtieth of the value heretofore ascribed to it on Leverrier's authority, of the lunar equation in the movement of the Earth. The irregularity in question, which arises from the revolution of the Earth round its common centre of gravity with the Moon, is reflected in a small monthly oscillation of the Sun as well as of other exterior bodies, diminished of course in the inverse ratio of their distances. The correction now applied to its amount could only have been arrived at by means of observations accordant among themselves to within considerably less than one tenth of a second of arc. If, however, the extent of the Earth's lunar orbit be less than had been supposed, it follows that the mass of the Moon had been proportionately over-estimated. And its concluded diminution by above one per cent. constitutes the third special result from the operations of 1889.

Plainly, then, the general adoption of the heliometric method would raise planetary astronomy to a far higher level than it at present occupies. Quite new possibilities would dawn upon planetary theory if a homogeneous mass of materials at least five times more trustworthy than any hitherto procurable could be placed at the disposal of investigators in celestial dynamics. But the attainment of this desirable end is subject to two conditions. International co-operation must above all be secured. One large scheme must be worked out in its various parts, in observatories scattered widely over the globe. For the purpose of the Victoria determinations three continents combined their forces. Twenty-two transit-instruments and five heliometers were brought to bear on the execution of a common plan. For the creation of a routine-branch of astronomy modelled on this special effort, a still more complete and widespread organization would be needed. Astronomy is, however, becoming every day more cosmopolitan. The habit of combination has been established; the machinery of combination has been constructed, and set going. There ought, then, to be little difficulty on this score.

If it were only a question of substituting for meridian observations the system of tracking the planets among known stars, the barriers should fall at the first blast of the trumpet. But before the full advantages promised by this substitution can be reaped, an obstacle of a fundamental kind must be removed. Dr. Gill has brilliantly succeeded in determining with almost ideal accuracy the *relative* positions of a suitably chosen set of stars, and of a body moving among them; and this suffices for many important purposes. Dynamical research, however, demands *absolute* places, which are not easily obtained. They cannot be had at all without referring to the Sun; and solar observations of precision are hampered by peculiar causes of uncertainty. The troublesome question of latitude-variations is besides involved. After looming long in the distance, it is now at last in full evidence, and can no longer be ignored in any discussion connected with practical astronomy.

The state of affairs, accordingly, is this. Relative determinations can be made with almost any desirable exactitude; but absolute determinations remain unsatisfactory. The place of every fundamental star is, in fact, affected by an uncertainty amounting, at the very least, to one third of a second—a gross quantity in heliometric work. Can this be remedied? and how? These are among the leading questions which Dr. Gill desires to submit to the deliberations of an astronomical council of nations.

There can be little doubt that means will sooner or later be found to render his improvements completely effectual. Science cannot voluntarily resign itself to imperfection: least of all in this age of crowded and turbulent advance. Astronomers accordingly, while they labour in the present, may safely trust to the future.

68 Redcliffe Square, S.W. A. M. CLERKE.

Sirius and Procyon.

In the June number of 'Astronomy and Astro-Physics' are two papers—one "A Graphical Method for determining the Apparent Orbits of Binary Stars," by Charles P. Howard, dealing with star-measures of Sirius from 1862 to 1890; the second "The Variable Proper Motion of Procyon," by S. W. Burnham, founded upon measures made by Otto Struve between the years 1850–90—which have no apparent connection with one another when viewed in the light of the immediate purposes of publication, but which, I think, may be shown when taken together to afford a basis for some curious reflections. Mr. Howard for the purposes of his paper has taken a series of observations of the relative positions of Sirius and its companion, collected together by Mr. Burnham and published in the 'Monthly Notices' of April 1891; and the general result of his paper is that the best elliptic orbit he can deduce, after trying twenty, does not satisfy the observed positions to the extent that their trustworthiness would seem to warrant, and that there are large systematic divergencies from this orbit between the years 1862 and 1869 and 1878–90. In fact he finds these two periods a veritable Charybdis and Scylla, and as a last resource he adopts the assumption of an epicyclic orbit—that is, that Sirius has a close companion, and these two together move in an orbit about the third,—and this assumption seems to satisfy the measures in a remarkable degree, even better than the trustworthiness of the observations would seem to warrant. Such an assumption that a binary system is, like matrimony, a committee of two with power to add to their number, is not a novel way out of the difficulty—the only difficulty is to find the disturbing body. Mr. Burnham's paper treats of the micrometrical measures of the difference in declination of Procyon and two adjacent stars made by Otto Struve between the years 1850–90, and lately published in vol. x. of the Pulkowa Observations. These observations were made for the express purpose of determining the amount, direction, and character of the proper motion of Procyon, and particularly with reference to the question of its variability.

In an accompanying diagram Mr. Burnham has given the observed corrected differences of declination (he does not say how they have been corrected, but we may assume that Auwers' corrections for proper and orbital motions have been applied), from which it is apparent that the points representing these differences do not lie on a straight line, as would be expected if the proper motion and orbit adopted accurately represented the facts, and the maximum discrepancy occurs about the epochs 1863 and 1885; it would have been interesting, for reasons given below, if the author had also tabulated in a graphical manner the observed differences of R.A. Mr. Burnham remarks in his paper that "it would be of interest to present in graphical form all the apparent variations as shown by work with the meridian circle, so that the consistency and value of the data could be submitted to tests which cannot be applied to tabular test." Within the last year such a graphical presentation of the Greenwich Transit Circle observations has been made by me in the case of many stars, including the two whose names head this paper, and the results for these two show characteristics strikingly in accord with those given by Mr. Howard and Mr. Burnham.

It happened that, in preparing the Greenwich Five-year Catalogue of Fundamental Stars for 1890, it was necessary to compare star places as observed at Greenwich between 1887–91 with the places of the same stars as deduced from the Greenwich Ten-year Catalogue, 1880, and as in the course of this work it was noticed that the differences for some of the stars appeared large and systematic, a more detailed examination was made. The observed places of Procyon and Sirius for the years 1836–91 were reduced to the epoch 1890 by the use of Peters' constants and Auwers' proper motions, the means, both of R.A. and N.P.D., of all consecutive seven years' results were taken, in order to eliminate effects due to the seven-year period of the latitude variation as adopted by Dr. Chandler, and these means were plotted as ordinates with time as the abscissa. A mean line drawn through the points thus laid gives the apparent correction to the assumed proper motion. In the case of Procyon, Prof. Auwers' values appear to be substantially in accord with the Greenwich observations, but those for Sirius require small corrections. Correcting the observations for the motions thus indicated, and laying down the corrected means of R.A. and N.P.D. as ordinates and abscissæ respectively, the observed orbits thus laid down show marked disturbances of varying character at nearly equal intervals of time and at nearly similar dates. After a great deal of time and trouble had been expended over these discrepancies, they were at last reluctantly set down to systematic or accidental errors. Now comes the remarkable fact. The periods 1860–68 and 1880–90 which trouble Mr. Howard, cover two of the periods of disturbance in the Greenwich transit-circle observations of Sirius. These same two periods mark the times of maximum variability in the proper motion of Procyon as given by Mr. Burnham in the above paper, a variability which is also supported by the Greenwich transit-circle observations. The mutual support thus shown to exist between the double-star and transit-circle observer has been further strengthened by Mr. Lewis, who finds that in the case of ζ Herculis, and in that of several other double stars, similar sympathetic relations exist between the transit-circle observations and the micrometer measures. Speaking generally, the case may be summed up as follows: double-star observers find certain peculiarities in their observations which are fully dealt with by Mr. Burnham in a paper on invisible double stars, 'Monthly Notices,' vol. li., and which appear to be only explicable on three suppositions: firstly, there are inherent systematic errors in the observations; secondly, there is a disturbing cause peculiar to the system; thirdly, there is some unknown disturbing cause outside the system. For binary substitute bright star, and a considerable study of sixty years of Greenwich transit-circle observations has driven me to somewhat similar conclusions. A few more coincidences like the ones described above would naturally excite a feeling that there may be "more in heaven and earth than is dreamt of in our computations."

Blackheath, 1894, June 23. W. G. THACKERAY.

Selenographical Notes.

GOCLENIUS.—This fine ring-plain, standing south-west of Guttemberg on the eastern side of the Mare Fœcunditatis, bears considerable resemblance, both in shape and in other respects, to Plinius, and, like this formation, is associated with a remarkable system of clefts. The border on the west side is tolerably regular and only broken in two or three places, on the S.W. by a large deep crater (*a*) shown by Schmidt and Neison, and on the N.W. by a somewhat larger depression (*b*), which does not appear in their maps. It is also traversed by a fine and particularly distinct valley running from the latter to the former. A little west of *a* the continuity of the rampart is again interrupted by a rocky mass which cuts through it at right angles and extends some distance beyond the limits of the outer slope of the border, and a similar but shorter buttress lies on the east of *a* and causes another dislocation in the wall. On the east, the circumvallation is of the linear type and much more broken and irregular, exhibiting many spurs and curved projections both internally and externally, and in some places indications of terraces. The low northern border meets it nearly at right angles and is perfectly linear for a great portion of its length, terminating on the west at a triangular shaped crater (*c*). Between the depressions *b* and *c* the wall is very low and appears to have been partially wrecked. If it be examined under good conditions when the eastern side of Guttemberg is on the morning terminator, distinct traces of this ruin will be observed in the shape of a number of short mounds, extending from the site of the wall for some distance on to the floor.

The interior of Goclenius contains a small, bright, but not very lofty central mountain, remarkable for the peculiar oblong form of its shadow, three smaller elevations on the east of it, and some low hills on the southern portion of the floor. Though frequently searched for, I have never seen any craters or minor depressions thereon.

With respect to the clefts, that marked ψ in Neison's map 22 traverses the floor from wall to wall, commencing at a point some distance east of the crater *a* on the south-west wall, and, passing close under the east flank of the central mountain, runs up to the northern border at a place about midway between the crater *c* and north-east corner of the formation. Beyond the border, opposite the spot where the cleft apparently terminates, is a dusky ill-defined object, probably representing a low hill with steep sides. At the north edge of this the cleft appears again as a tolerably coarse object and runs to the west side of Guttemberg *e*, the outer slope of which it appears to graze but not to traverse, to the end of a mountain-arm west of Guttemberg *g*, where it terminates. Both Schmidt and Neison show the cleft ψ as originating at the crater *a*, passing west and not east of the central mountain, and running up the crater *c* on the north wall; and, moreover, though it is not drawn as an extension on the floor of any of the other clefts outside, they do not show that it is more likely to be a prolongation of the most easterly member of the system than of either of the two other clefts which run parallel to it, which is clearly the case. Fourteen years ago I detected a second cleft on the floor of Goclenius that had not been previously recorded. It commences at the inner foot of the north wall, a little east of the crater *c*, and runs nearly parallel to ψ, traversing in its course the short low mounds on the floor just referred to, and extending to a point a little north-west of the central mountain. Schmidt represents three parallel clefts running in a north-easterly direction from the north wall of Goclenius; the most easterly of these is that which terminates near Guttemberg *e* and which I believe is a prolongatin of the cleft ψ on the floor, though he and Neison represent it otherwise. The remainder are drawn as dying out on the surface of the Mare about 30 or 40 miles north of Goclenius and are consequently scarcely half the length of the other. In this he is clearly wrong, for Neison traced the intermediate cleft to a hill south of Lubbock and the other almost as far, and I have frequently followed them easily to these points, though the bifurcation he draws in the intermediate cleft has not been noted. A feature resembling a "fault" may be seen under suitable illumination extending from the west wall of Guttemberg at right angles to the clefts and crossing the two westerly members of the system a little south of the place where Schmidt makes them terminate. He represents it as a narrow low ridge, but its clean-cut black shadow shows that it has a vertical face, or nearly so.

Beaumont House, Shakespeare Road, THOS. GWYN ELGER.
Bedford, 1894, June 19.

Potsdam Photometric Observations.

THE enterprise of the staff of the Potsdam Observatory has exhibited itself in various ways, and shown in many fields of enquiry how far a well-directed and sustained effort can adequately cope with laborious investigation. But the ninth volume of the thirty-first publication discloses a scheme, the magnitude of which dwarfs many of the efforts of others in the same department and to some extent exceeds the limits of their own previous enquiries. This scheme has for its complete realization. the determination of the photometric magnitudes of all stars in the Northern Hemisphere, represented in the 'Durchmusterung' as of the 7·5 mag. or brighter. This, it will be perceived, does not quite amount to the same thing as all stars of the 7·5 mag., for as that limit of magnitude is reached it is inevitable that many stars must have been included by the original observers of the Bonn Catalogue which do not reach that brilliancy, while others have been classified as fainter and now escape a revision. The work of photometrically examining all these stars was commenced in October 1886, and has apparently been continued uninterruptedly by the two observers Drs. G. Müller and P. Kempf, to the effect that about one-third of the work is now complete, and the authors are able to put before the astronomical world the results of their investigations on the stars included in the zone from the equator to the 20° N. declination. For a reason which will appear presently the amount of work accomplished in this time is greater than that here mentioned, and consequently the successive portions of the work may be expected to appear at shorter intervals than this statement would suggest.

But probably not much less than twenty years will be requisite for the complete attainment of the object contemplated, and this expenditure of time and labour the authors consider justified by the cosmic importance of the problem. This judgment is probably well founded. They are at work at a branch of astronomy which, notwithstanding the efforts of individuals in the last few decades, is still in arrear. The attention which the subject has recently received in England and America is a warranty that still more workers are needed in this harvest. The point of view from which Drs. Müller and Kempf regard the problem is one of equal importance with the spectroscopic examination of the stars, and must go hand in hand with it. Notwithstanding the reasons given by the authors, this view will probably be questioned by the spectroscopists.

At the outset of an enquiry of this extent there are many preliminary points which have to be definitely settled, and it is interesting to notice how far the labours of others have influenced decision in the present instance, and to what extent Profs. Müller and Kempf have acquiesced or differed from the judgment of other experts. In the first place there is the choice of instrument; and it will surprise no one to learn that the form of photometer selected is that known as the Zöllner. Probably it would be more correct to say that, however admirably the Potsdam observers have balanced the advantages and disadvantages accompanying the use of other forms of photometer, everyone would have been surprised had the decision been different, so complete is the hold that this particular form of photometer has obtained in Germany. Passing over the Herschel and Seidel forms, which may be regarded as obsolete and on various grounds out of court, these indefatigable observers find themselves confronted by three recognized methods, all of which have particular claims to notice, and for a final decision on the relative merits of each probably a sufficiency of material does not exist. These three are the wedge photometer, the Pickering meridian photometer, and finally the Zöllner. To the first of these no objection is raised on the score of accuracy of results, and with equal readiness are admitted the comparative inexpensiveness of the apparatus, its ready application to any form of telescope, and its convenience in use. On the other side are urged the difficulty, if not impossibility, of procuring glass free from selective absorption out of which to manufacture the wedge, and the trouble of accurately determining the constant of absorption—a source of error which increases with the difference of brilliancy in the two stars to be measured. This last objection is probably not over-estimated. Recent enquiries seem to show that corrections are still necessary to the value employed by Prof. Pritchard in his Oxford work; but it is not unimportant to remember that these corrections, whether they arise from local deterioration in the polish of the wedge itself, or from relying on untrustworthy methods in the original determination, are susceptible of easy application, at least so long as the brilliancy of the stars are referred to a single standard. The final conclusion to which the authors are led is one in which Prof. Pritchard would himself probably have concurred, viz.: that the wedge photometer is admirably adapted for the discussion of the difference of lustre of two stars not very widely separated in the sky and not differing greatly in brilliancy or colour. If it be necessary to determine the magnitude of stars of very different brilliancy, recourse must probably be had to successive steps, and this is practically the method which Profs. Müller and Kempf have adopted.

The Pickering photometer is next brought under review and meets also with rejection. Here, again, no exception is taken on the score of accuracy in the final results: the equalization of brilliancy is preferred, as less fatiguing to the eye, to the extinction of light, and the great advantage of the comparison being made between the star-images themselves, avoiding the introduction of an artificial star, is fully admitted. But the disadvantages are considered to outweigh. The fact that the instrument, as existing at least, must be used near the meridian, and the employment of two optical systems, with the possibility of bad images, owing to the rays having to pass through so many surfaces, are drawbacks with which the Potsdam astronomers decline to contend. But if they have much to say for and against other inventions, they readily admit the imperfections of the Zöllner. The searching investigation of Wolff's results by Pickering has disclosed peculiarities which tend to shake confidence in the use of that instrument. The want of exact similarity in appearance between the real and the artificial star is a defect which cannot be remedied, but care and attention seem to have removed the chance of error arising from variation in the flame of the lamp—a source of annoyance in the earlier constructed instruments, as Peirce found at Harvard. But notwithstanding this improvement, there is still to be feared the introduction of errors, which become noticeable when stars of sensibly different magnitudes are compared, the tendency being to make the observed difference of brilliancy too small. Ceraski believes that he has entirely overcome this difficulty; but his experiments are not conclusive, and the authors have no doubt shown a wise discretion when they limited the actual comparisons to practically 2·5 magnitudes. This limitation amounts to a confession that a trustworthy stellar photometer has yet to be invented. In the Potsdam Observations the difficulty has been avoided, it has not been remedied. Practically, three photometers have been used—one with an aperture of 13·5 cm. has been restricted to the fainter stars, one with 67 mm. aperture has been found useful for stars between the fourth and sixth magnitude, while the brightest stars have been measured with one whose available aperture was 36·5 mm., employing diaphragms when necessary. Here we have the process of successive steps distinctly followed, and in experienced lands doubtless with good effect. To this point we shall return next month.

Having selected the instrument, other points scarcely less important have to be settled. Among these may be mentioned: Should the results be published in a logarithmic form as Seidel and Wolff have done, or in more familiar form of magnitudes, employing some constant as Pogson's to effect the transition? The decision of the German astronomers will meet with general approval. They employ the ordinary notation and the ordinary factor, so that their results are immediately comparable with the published results of other astronomers. But though this decision is fortunate, there are not wanting indications that had they been absolutely unfitted by previous investigations we might have had a very different arrangement. For instance, the occurrence of negative magnitudes in a few instances is an inconvenient blemish that has generally been recognized. Whether any advantage would have resulted from the division into naked-eye stars and telescope stars, making the whole of one class negative and the whole of the other positive, is open to serious question, but the point has been practically decided by the mass of work that has been done on other lines. Pogson's coefficient is so exceedingly convenient, is so near the mean of the results of so many enquiries that have had for their aim the combination of photometric magnitude with the eye estimations of Argdander and others, that no gain could be expected from an alteration.

Two other points of considerable importance affect the arrangement of the work. Was it desirable to re-measure those stars, generally brighter than the sixth magnitude, whose brilliancy may be regarded as to some extent settled by the work of Profs. Pickering and Pritchard? and since stellar lustre must be relatively estimated, should a single star be selected as the standard or should there be many points of reference scattered throughout the heavens? If the first of these two questions had been decided in the negative, it would have reduced the amount of work by about one-fifth. In the catalogue before us we have 3522 stars, and of these about 800 are common to Pickering's first and second catalogue, and 700 to that of Pritchard. But the increase of the work, supplying as it did much material for valuable comparison of results by different methods, was not regarded, in consideration of the value that might be derived from it, and the authors resolved not to be content with simply extending older catalogues to embrace fainter stars, but that their work should exhibit the photometric magnitudes of the 'Durchmusterung,' determined by a uniform method and by the same observers. The result of this comparison must be deferred till next month. The second of these two questions cannot be sufficiently debated here. Suffice it to say that the authors have not relied upon comparisons with the Polar Star or any other, but have determined the magnitudes of a number of stars scattered over the sky, not limited to the particular district under observation. This has materially increased the labour of preparing this zone, but, in the opinion of the authors, has secured uniformity for the sections subsequently to appear and amply compensated for the extra labour and delay occasioned. W. E. P.

[To be continued.]

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Relative Magnitude of Stars.

GENTLEMEN,—

I fear that there must have been some want of clearness in my statements at the last meeting of the R. A. S. to account for the discussion which followed being so much astray from the points to which the paper directed attention. I would therfore solicit a little space in your pages to state, as concisely as possible, what those points were; premising that the subject was strictly limited to the question of the relative brightness of stars as shown in photographs of long exposure.

It is asserted that Dr. Roberts's photographs "present to the eye the true relative magnitude of the stars:" and in the latest edition (1893) of his 'Treatise on Photography,' Capt. Abney expresses the opinion that a reflector is the best telescope to employ for mapping the heavens, and *ascertaining the star-magnitudes.* Both statements I question.

Putting on one side the question of coloured stars, the only method, at present available to us, of judging whether one star in a photograph is brighter than another is from the area of the disk as photographed.

If on this method we compare photographs taken with a refractor and a Newtonian reflector, and employ only those disks which show full density in the silver deposit, we establish the following fact:—

Gradations of brightness which are perceptible to the eye in telescopic observation, are equally perceptible in refractor photographs, but are very much less perceptible in those taken with a reflector.

One cause of this anomaly is perfectly well known, viz., that the scales are different, the scale in the reflector photographs being much more condensed than in that of the refractor. That is, the range of areas of disks between any given magnitudes is much less in the former case than in the latter. The result of this is, that to the eye the reflector photographs present a conspicuous uniformity and equalization in the apparent magnitude of the stars, a fact that can be established by the simplest inspection; and the statement that, in this respect, the reflector photographs give an untrue portrait of the object can be completely substantiated.

Another point which plays an important part in this question, and which has never been well investigated, is the effect on the construction of the image of a star in reflector photographs, produced by the arms supporting the flat. The rays thus produced render long-exposure photographs of stars brighter than 6 magnitude valueless as indicating relative brightness; and, in the case of fainter stars, there are numerous indications in Dr. Roberts's photographs of these rays manifesting themselves to the distortion of the image, and the destruction of any correct inference as to the brightness.

No more interesting or instructive investigation could be undertaken than that of photographing stars with a reflector on the Herschelian construction. We should then be able to differentiate these methods, and learn the true value of a mirror for stellar photography. Meantime, and until that is done, the value of reflector photographs for indicating the "true relative magnitude of the stars" cannot be considered otherwise than small.

3 Tavistock Square,
1894, June 16.

Yours faithfully,
EDWARD B. KNOBEL.

OBSERVATORIES.

Laws Observatory. *Milton Updegraff.*—In a neat little brochure, vol. vi. no. 15 of the Transactions of the Academy of Science of St. Louis, we have a brief historical sketch and an account of the determination of the latitude, longitude, and height above sea-level of the Laws Observatory of the University of the State of Missouri. From this we learn that "The Old Observatory of the University of Missouri was one of the first institutions of its kind west of the Allegheny Mountains, and was for many years the only astronomical observatory in the United States west of the Mississippi river." The Observatory possesses a good 7½-inch refractor, furnished with a filar micrometer and a spectroscope, a transit instrument 2·1 inches aperture, and a zenith telescope of 3 inches aperture and 46 inches focal length. It was by means of the latter instrument that the determination of latitude was made by Prof. Ficklin. The new determination by Mr. Updegraff was made with the transit instrument in the prime vertical. The results being

Talcott's Method—Ficklin	Lat.	38° 56′ 51″·645 N.
T.I. in Prime Vertical—Updegraff..	Lat.	38 56 51 ·923 N.
Adopted Mean latitude		38 56 51 ·70 N.

The longitude was determined by exchange of signals with the Observatory of Washington University, St. Louis, in 1891.

Result: $6^h\ 9^m\ 18^s{\cdot}33$ West of Greenwich.

We hope to hear more of Mr. Updegraff, although he is somewhat hampered with his University duties.

Royal Observatory, Greenwich.—The Annual Visitation took place this year on Saturday, June 2, in better weather than was expected from indications of preceding days. A large company of between three and four hundred persons were present in response to the special invitation issued by the President of the Royal Society, including Sir Ughtred Kay-Shuttleworth, Secretary to the Admiralty, and other Admiralty officials. The entire Board of Visitors was present at the official meeting, a rather unusual circumstance. The principal attractions were the 28-inch refractor, the object-glass of which has been mounted since the previous visitation, and the completed wing of the new Physical Observatory in the south ground, which was opened for the first time. This is the first of four wings which are to surround the octagonal building to be used as a museum for obsolete instruments and those not actually in use, and on the topmost floor of which the 26-inch photographic refractor, to be presented by Sir Henry Thompson, is to be mounted.

The Astronomer Royal's Report gives the usual details of the work of the year, with numerical results in some cases and statistics. Two remarkable features are the large number of observations with the Transit Circle during the twelve months, about 11,000 as against an average of about 5500 for the previous seven years, and the large number of plates taken for the astrographic chart —220 for the chart, 387 for the catalogue. This large increase in the work is partly due to the exceptionally fine weather of 1893–94, details of which are given in the report.

The discussion of the observations of zenith distances of stars by reflexion gives for the numerical value of the formula for 1893 $+0''\cdot057+0''\cdot703$ ZD, which agrees well with the results for recent years. A suggestion made that the correction may be affected by the circumstance that the reflexion observation is in practice always made before the direct has led to the making of some observations in which the direct observation is made first, the discussion of which it is hoped may throw some light on this point. The co-latitude of the transit circle as found by the observations of 1893 is $38^\circ\ 31'\ 22''\cdot07$.

The dynamo surrounded by the triple shield for the purpose of preventing any ill-effects on the magnetometers, described in these pages (1893 Oct.), was mounted in the lower apartment of the south wing of the Physical Observatory last March, and has been running since March 29. No effect that can be detected has been produced by it on the Declination and Horizontal Force Magnets.

An unusually large number of changes in the staff, considering the comparatively small number of persons forming it, have taken place since the last report. Besides the resignation of Prof. Turner, consequent on his appointment to Oxford, and the retirement of Mr. Ellis on account of the official regulation in respect to age, one other assistant has resigned, and the Admiralty clerk in charge of the accounts has been changed twice.

The Board of Visitors with a rather small company dined at the Criterion Restaurant, under the Presidency of Lord Kelvin.

THE HARVARD OBSERVATORY IN PERU.—Prof. W. H. Pickering has recently published in an American magazine an account of the work done at the observatory at Arequipa, founded and endowed in accordance with the will of Mr. Boyden, since its establishment in 1891. The record of work is summarized in two classes, original and routine work: the latter consists of photography of stellar spectra, the making of photographic star charts (the report says "charts of every portion of the sky within this region have been made showing all the stars visible of the 13·0 magnitude and upwards. This gives Harvard Observatory the first and only complete chart in existence of the whole heavens"), and miscellaneous celestial photography. Under the head of original discoveries are included some discoveries of close double stars, observations of the surface of the Moon, for which the altitude of the station is particularly suitable, physical observations of markings on Mars at opposition and of Jupiter's belts and satellites, and the discovery of a new star in Norma by Mrs. Fleming, already announced in these pages. Altogether a very creditable record of work for three years.

Mr. Tebbutt's, Windsor, N. S. Wales.—In his report for the year 1892 Mr. Tebbutt stated that the time was at hand when he should for a period have to seek some relaxation from astronomical work. We gather from the report for 1893 now before us that this projected holiday did not follow very closely on the above statement, nor is it to be a very protracted one. The work done in 1893 is quite equal to that of former years, as will be seen from the following summary of the report:—transit observations for time determination on all available nights, 45 observations of occultations of stars by the Moon, occultation of Saturn, micrometer observations of the conjunction of Saturn and γ Virginis, observations of position of two minor planets (Hebe and Parthenope) on 13 nights in all, comet observations (Brooks 1892 and Rordame-Quénisset) on 73 nights, and a series of observations of the star α Centauri made at the request of Dr. T. J. J. See of Chicago, and used by him in his investigation of the orbit of this binary. This is truly a wonderful record of work for one man, and who, besides, makes the greater part of the reductions himself. In his last paragraph Mr. Tebbutt proposes as his work during the first half of 1894 to observe occultations only, and to make only time determinations necessary for these, but "should a southern comet appear to obtain a number of positions sufficient for a fairly good determination of its orbit." This last, as may be seen on p. 230, is already *un fait accompli.* This programme, with the superintendence of the building of the new brick chamber for his 8-inch refractor, which is in progress, cannot leave Mr. Tebbutt much leisure for relaxation. He hopes to recommence *regular* work by the middle of the year.

PUBLICATIONS.

Observations of Neptune's Satellite with the 30-inch Refractor at Pulkova. By Hermann Struve. (Memoirs of the St. Petersburg Imperial Academy of Science, Vol. xlii. No. 4.)—This work contains not only a valuable series of observations of the satellite extending over eight years (1885–93), but also a discussion of the systematic errors of this and the other extant series of observations, and a computation of the definitive elements of the satellite and the mass and diameter of the planet. The observations of position-angle were made in three ways:—(1) with a single bright wire in a dark field; (2) with two parallel bright wires, between which the objects are symmetrically placed; (3) with a single dark wire in a faintly illuminated field. A number of double stars, comparable in distance and magnitudes with the planet and satellite, were observed to deduce the systematic errors of these different methods, which are fully discussed. The author always places the two objects either parallel or at right angles to the line joining the eyes, as there is evidence of the observed position-angle being affected by the slope of the line joining the objects.

The observations are divided into four series, and the corrections to the assumed elements deduced from each series separately, the results showing a very satisfactory agreement. The following are the definitive elements for 1890·0 from all available observations:—

Longitude of satellite reckoned from Node	234°·42
Mean daily motion	61 ·25748
Node (referred to equator)	$185\cdot15+0^{\circ}\cdot148\,(t-1890)$
Inclination („)	$119\cdot35-0\cdot165\,(t-1890)$

Semi-axis major of orbit from H. Struve's observations (at distance of planet whose log is 1·47814) 16″·271.

The Washington observations give values ranging from 16″·263 to 16″·602.

Mass of Neptune from H. Struve's observations $\frac{1}{19.396}$.

Of the eccentricity of the orbit it can only be asserted that it is less than 0·01, since the results of different observers differ greatly. H. Struve's results alone give 0·007, and the longitude of nearer apse 259°.

The motion of the node of the orbit was first pointed out by Mr. Marth ('Monthly Notices,' vol. xlvi. p. 505). The most probable cause is the compression of the planet, whose equator must in that case be considerably inclined to the satellite's orbit. M. Tisserand has shown that the compression of the planet, if homogeneous, need not exceed $\frac{1}{100}$ to explain the observed phenomenon; in this case it could not be detected by observation. The diameter of Neptune, deduced from the present series of observations, is 2″·210 at the distance whose log is 1·4742. The observations gave a slightly less diameter in the direction of the major axis of the satellite's orbit than at right angles to this, but only within the limits of accidental error. The observed diameter was found to diminish as the illumination of the field was increased. This diameter agrees closely with that deduced by Lassell and Marth with Lassell's great reflector in Malta. Smaller instruments have given considerably larger results.

THE AMATEUR TELESCOPIST'S HANDBOOK *.—This is an unpretentious but excellent book, and is likely to be found of great service by the amateur star-gazer. This last word is not used in any opprobious sense; the author himself defends the term, and while believing that the day is past when the amateur with a small instrument is able to help much the cause of exact science, allows that there is much pleasure in merely looking, and caters for his wants with a satisfying liberality. After a chapter on the Principles of the Telescope, the book contains chapters on Testing the Object-Glass, the accessories of, the care of, and the use of the Telescope, all very practical, and then,

* 'The Amateur Telescopist's Handbook.' By Frank M. Gibson, Ph.D., LL.B. Longmans, Green, & Co.: London and New York, 1894. Price 3*s.* 6*d.*

more practical still, a chapter giving the Prices of Telescopes of not more than 6-inch aperture, and their accessories, as quoted by different makers. Besides other sections on the various celestial objects stating what an observer with a small telescope may expect to see on each, the book contains a descriptive catalogue, compiled chiefly from Admiral Smyth's cycle, of 468 celestial objects, with a section on "Alignment Stars," which is a sort of *memoria technica* for one learning the aspect of the visible heavens. There seems to be in this book all that the beginner who possesses a small telescope can want.

NOTES.

Comet Notes.—'Astronomy and Astro-Physics' for June contains a reproduction of one of several successful photographs of Gale's comet taken at Mount Hamilton by Prof. Barnard. The tail could be traced for fully 10°, as a slender nearly straight ray, which on some of the plates seemed to begin 1° distant from the head, but on others could be traced right up to the latter. On May 4 two other tails could be traced, each about 1° long, on opposite sides of the main tail. Prof. Barnard remarks:—"The peculiar characteristic of this comet is its slender tail and round head. There was no apparent development of the head as usual in comets possessed of a tail—that is, there was no apparent diffusion of the material of the head to form the tail."

Prof. Campbell photographed its spectrum, and could trace more than 20 lines; the spectrum appeared similar to that of Comet *b* 1893 (Rordame-Quénisset).

The following ephemeris is for Berlin midnight:—

	R.A.			N. Decl.			R.A.			N. Decl.	
	h	m	s	°	′		h	m	s	°	′
July 3..	12	13	28	43	29	July 19..	12	41	54	43	28
7..		20	44		33	23..		49	0		24
11..		27	53		34	27..		55	57		18
15..		34	54		32	31..	13	2	54		10

On July 31 the brightness will be $\frac{1}{25}$ of that at discovery.

An interesting memoir by H. A. Newton has recently appeared on the subject of the capture of comets by Jupiter; it forms Vol. VI. No. 1 of the Memoirs of the National Academy of Sciences. His principal conclusions may be summed up as follows:—Out of 1000 million comets moving in parabolas that approach the Sun nearer than Jupiter, 126, 839, 1701, and 2670 will have their orbits changed into ellipses with periodic times less than 6, 12, 18, and 24 years respectively. These numbers would be greatly increased by the consideration that a comet whose orbit was changed into an ellipse with any eccentricity would be almost certain sooner or later to make another approach to Jupiter and might then undergo a further shortening of its period. Of the 839 comets mentioned above, 203 will after perturbation have retrograde motions and 636 direct; of the same 839 comets, 5 times as many will move in direct orbits inclined less than 30° to Jupiter's orbit as in retrograde orbits inclined less than 30° to it. A. C. D. C.

Minor Planet Notes.—Prof. Barnard has obtained by direct measurement with the Lick refractor the following diameters of the principal minor planets:—Ceres 599 miles, Pallas 273 miles, Vesta 237 miles; Juno estimated about equal to Pallas and Vesta. If the diameter of Vesta be correct, it must have a high albedo to account for its relative brilliancy. A. C. D. C.

On the Determination of Absolute Right Ascension.—In a paper read at the meeting of the Royal Astronomical Society reported in our last number, the authors pointed out the source of an error which may under some circumstances be of serious amount in the determination of star-places; and as at the present time the subject of accurate determination of such places is under discussion on the initiative of Her Majesty's Astronomer at the Cape, it may not be out of place here to give a short explanation in terms as untechnical as may be of the process of finding absolute Right Ascension, which the error referred to in the above mentioned paper would affect. It is perhaps scarcely necessary to explain the first step in finding Right Ascension: the clock time of transit of a star (in which term the Sun and other celestial bodies is included) is recorded, which time is corrected by the application of a clock error, deduced from similar observations of certain other stars, called generally "clock-stars."

On consideration it is clear that this process simply amounts to finding *differences* of right ascension, *differences* between stars and the clock-stars; and to convert these differences into absolute right ascension it is necessary to choose some point or rather some celestial meridian as a *zero*: if the clock-stars are already referred to the zero, naturally the measures which we have defined as differences are absolute right ascensions; but it is in the fixation of the zero and in the referring of celestial bodies to it that the error we are now considering occurs.

The point chosen as zero is the point of the sky in which the centre of the Sun is at the moment when (going northward) its N.P.D. is exactly 90°.

It will be seen that there are two obvious sources of error:—

(1) The *differences* of right ascension between the Sun and the stars may be in error.

(2) There may be error in measuring the N.P.D. of the Sun, and hence the wrong moment may be taken as the critical moment when the N.P.D. is 90°.

In connection with (2) it is to be remarked that it is improbable that the Sun would be on the meridian when the N.P.D. is exactly 90°, nor if it were would it be expedient to rely on this single observation of N.P.D.; hence this critical instant of zero declination is deduced from all observations of the Sun throughout the year by aid of the Solar Tables, and we have thus the error of these tables as a possible third source of error.

With reference to (1), the paper referred to above pointed out one cause of such error, viz., that an observer's personal equation might not be the same for the Sun as for stars, and hence the measured differences would be in error. Another cause might be the uncertainty of the clock-rate adopted between the observation of the Sun and the stars.

With regard to (2) it is to be remarked that any error of uncorrected refraction will here have a large effect, unless, indeed, this uncorrected error should chance to be symmetrical and have opposite sign at opposite periods of the year, in which case he mean value will be correct, since observations throughout the year are used.

In actual practice of compiling star catalogues the equinox or zero of R.A. is often not deduced from observations of the Sun as above indicated; in fact there are comparatively few observatories which make daily meridian observations of the Sun, but some system of stars, such as the Greenwich lists of clock-stars, is used as fundamental, and the resulting catalogues therefore give right ascensions with the same zero-point as that of the adopted system. The Greenwich catalogues are naturally formed in the first instance from the Greenwich lists, and finally corrected for the error of equinox found from the observations of the Sun. May it be suggested as an item in the programme of the International Conference proposed by Dr. Gill that all the observatories of the world should combine in using for certain periods the same system of stars in formation of their catalogues? Such an arrangement would save much labour in the comparison of catalogues and would be of much advantage in detecting local differences.

ON THE PARALLAX OF 70 OPHIUCHI. BY W. SCHUR.—Prof. Krueger, in the years 1858–62, observed this double star for parallax at Bonn, using two comparison stars distant about 30′ on opposite sides of it. He selected the faint companion star as being more comparable with the comparison stars in magnitude, and used Klinkerfues' orbit in correcting the results for orbital motion. Prof. Schur has made a new investigation for parallax with the Göttingen heliometer, making the comparison with the same two stars, but using the brighter star of the pair, its light being reduced by a screen which rendered its faint companion almost invisible. The comparison stars have been observed several times on the meridian, and appear to have no sensible proper motion; for 70 Ophiuchi itself Auwers' proper motion is used. From eight nights' observation in 1891 the resulting parallax is 0·286 ± ·031, while Krueger had made it 0·150 ± ·006. Prof. Schur examines whether the assumption that the mass of the companion is appreciable will reconcile the results, but finds that this is not the case. If we assume a parallax of $0''\cdot2$, the resulting semi-axis major of the relative orbit is 23 units, the distance from the solar system 1,000,000 units (=16 light years), and the mass of the system 1·6 times the Sun's.

THE PARALLAX AND PROPER MOTION OF ALGOL.—It will possibly be remembered that the periodic fluctuations of brilliancy of this variable are subject to some irregularities, which Dr. Chandler, in a comparatively recent paper, ascribed to a revolution of Algol and its dark companion about a third body as a primary in a period of about 130 years. If this be the fact, it would follow that the parallax of Algol should be about $0''\cdot07$. Dr. F. L. Chase, of Yale University, was induced to observe Algol with the Yale heliometer for the purpose of verifying, if possible, this theoretical parallax. Taking two pairs of comparison stars, he made measures of the distances of Algol from these in March and July, 1892, February and August, 1893. The result published in the 'Astronomical Journal,' No. 318, gives for the parallax $+0''\cdot0363 \pm 0''\cdot0202$ "about half the value given by Dr. Chandler's theory, and yet, while the result does not positively corroborate, it is not of such a character as to render the theory improbable." Dr. Chase further attempted to find the proper motion of Algol by comparison with the comparison stars, on the assumption that these latter had no proper motion (an attempt to find such proper motions having proved abortive), and finds for Algol

$$\Delta\alpha \cos\delta = -0''\cdot034 \pm 0''\cdot035, \qquad \Delta\delta = +0''\cdot014 \pm 0''\cdot046,$$

as against Dr. Chandler's

$$\Delta\alpha \cos\delta = +0''\cdot0449, \qquad \Delta\delta = +0''\cdot0120;$$

but he does not consider these results as very trustworthy, for, as he says, "a year and a half of heliometer observations is hardly sufficient in point of time to determine so small a relative proper motion with any great reliability, as is shown by the magnitude of the probable error."

A COMET IN THE CORONA OF 1893 APRIL 16.—The following is extracted from the 'Astronomical Journal,' No. 318:—"In a paper read before the Astronomical Congress at Chicago last August, immediately after my return from the Lick Observatory Expedition to Chile, particular attention was called to a comet-like structure visible on all the Lick Observatory negatives of the outer corona. As the interval of time between the first and last of these photographs was less than three minutes, a daily motion could not be determined with certainty. Two days ago we secured positive copies of the negatives taken by the English expeditions to Brazil and Africa, and with the aid of the additional data thus furnished the suspected object is shown to be a comet having at the time a daily geocentric motion of about three and one quarter degrees away from the Sun in the position-angle 200°.—J. M. SCHAEBERLE (1894 May 9)."

In another article on the subject in the same number of the journal, Prof. Schaeberle explains how he measured the position of the comet on the negatives from the centre of the Moon, and gives the resulting R.A. and Dec. of the comet at three epochs at intervals of about an hour and a quarter. He concludes: "The truly remarkable appearance of this particular object on my eclipse-negatives, so plainly showing an apparent connection with a singularly slender but conspicuous streamer from the Sun, finally induced me to announce the 'Mechanical Theory of Comets,' as giving additional evidence in favour of the 'Mechanical Theory of the Corona.'"

With reference to what Prof. Schaeberle says about the positive copies of the English photographs, it is important to remark that the original negatives have been carefully scrutinized by Mr. Wesley and others for this comet, but without success, although Prof. Schaeberle kindly sent minute directions where to look for it.

In the 'Astronomische Nachrichten,' No. 3220–21, Herr W. Schur gives a complete discussion of the orbit of the binary star 70 Ophiuchi. He has, in general, applied no correction for systematic errors; but he makes exception in the case of OΣ and in the Cincinnati observations—in the former case "nach seinem Wunsche die 'Observations corrigées' angewandt worden sind," and in the latter case because they are already included in the reduced yearly means. The actual computations were made with a combination of Herschel's analytical method and Seeliger's formulæ (used by Schorr in his discussion of ξ Scorpii).

The definitive elements are:—

T = 1808·07 and 1896·47.

☊	121° 19′	1850·0.	ε	0·4751.
ι	60 5		η	−4°·0726.
λ	168 18		P	88·40 years.
φ	28 22			

Mr. S. C. Chandler has recently been awarded the Watson medal, the bestowal of which is a trust held by the National Academy. This medal was founded by Prof. James Craig Watson, of Wisconsin, U.S., who is perhaps best known as the author of an excellent treatise on Theoretical Astronomy, but also as a firm believer in the existence of an intra-Mercurial planet.

Mr. J. Ritchie thus writes of the latest recipient: "As a scientific man he finds himself within the circle of the elect, and in the company of the greatest astronomers of the decade. Four medals only have been given: the first to Dr. B. A. Gould in 1887; the second to Prof. Edward Schönfeld, Director of the University of Bonn, in 1888; the third to Dr. Arthur Auwers, of Berlin, in 1891; and the fourth to Mr. Chandler."

Erratum.—In the report of the R. A. S. Meeting in our last number, on page 200, the names of gentlemen elected Fellows and of those proposed for election were inadvertently transposed.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 217. AUGUST. 1894.

BRITISH ASTRONOMICAL ASSOCIATION.

The concluding Meeting of the fourth Session of the British Astronomical Association was held in the Botanical Theatre, University College, on Wednesday, the 27th June, Dr. A. M. W. Downing, M.A., F.R.A.S., President, occupying the Chair. The election of five new Members by the Council was confirmed by the Meeting, and the names of five Candidates for Membership were read and suspended.

Among the presents received was a set of photographic slides of nebulæ presented by Dr. Isaac Roberts, together with a copy of his valuable book, 'A Selection of Photographs of Stars, Star-Clusters, and Nebulæ.' The President further announced that Dr. Roberts had offered thirty copies of the book to Members of the Association at a considerably reduced price. The thanks of the Meeting were accorded to Dr. Roberts and other donors.

Messrs. Thomas Lewis and W. Gordon Miller were elected Auditors, and Messrs. Benson, Kennedy, Hollis, and Meares were appointed by the President Scrutineers of the ballot.

A note was read from *Miss Brown* on a remarkable Sun-spot appearance observed by her on the 26th June at 6 P.M. A spot nearing the W. limb and considerably foreshortened exhibited a cup-like cavity which suddenly became half filled with a brilliant red glow, like flame-colour.

Capt. W. Noble then remarked that he had occasionally observed a similar phenomenon, and although not a common occurrence it was not absolutely infrequent.

A paper by *Mr. Sidney Waters, F.R.A.S.*, on "The Distribution of the Nebulæ and Clusters in Space," was next read. The paper was accompanied by charts illustrating the grouping of nebulæ and clusters. The writer referred to the old theory that clusters, resolvable and irresolvable nebulæ, were all of the same character, and that difference in distance accounted for the difference of resolvability. The spectroscope and photography had to a great extent disposed of this theory, and the evidence of distribution as indicated in the charts seemed completely to dissipate it. The distribution of matter appeared to have been favourable to the production of clusters in the Milky Way and of nebulæ elsewhere.

Dr. Dreyer, F.R.A.S., remarked that the distribution of nebulæ in space had been investigated by Dr. Bauschinger shortly after the publication of the 'New General Catalogue,' and his conclusions agreed perfectly with those of Prof. Cleveland Abbe and Mr. Waters. This was important, as showing that the very faint nebulæ detected during the past thirty years were distributed exactly as the brighter ones were, the maxima being about the poles of the Milky Way. The planetary nebulæ, on the other hand, were, almost without exception, situated in or very close to the Milky Way, as were also to a large extent stars with Sirian spectra, pointing to the probability that the Milky Way was in an earlier stage of evolution as compared with other regions of the universe.

Mr. E. Walter Maunder, F.R.A.S., remarked that the subject dealt with by Mr. Waters was closely related to Prof. Pickering's researches concerning the distribution of stars of the fifth or Wolf-Rayet type. They all lay along the equator of the Milky Way. These various facts all pointed to the conclusion that the visible sidereal universe was, for the most part, but one single organism. The systematic grouping of the various orders of celestial objects could not be accidental.

In reply to a question from the President, *Dr. Dreyer* said he was not aware of a single well-authenticated instance of proper motion or change of form in a nebula.

Capt. Noble urged that if any observations for parallax were undertaken it would have to be by photography, and inquired whether photography had ever been applied to this purpose.

Mr. E. W. Maunder believed not; and was not aware of any satisfactory measurements of the parallax of any nebula having yet been made.

Miss Alice Everett read a paper by the Rev. W. R. Waugh, F.R.A.S., on the "Latitude of Jupiter's Belts." In consequence of Mr. Holmes' criticism of Prof. Keeler's drawings of Jupiter, exhibited at a previous meeting, Mr. Waugh had carefully measured 50 drawings selected from 254 drawings by members, the results of which he submitted in tabular form. He considered that they confirmed in a remarkable degree the accuracy of the very beautiful drawings of Prof. Keeler.

Mr. Holmes expressed his surprise that a casual remark of his should have excited such attention. He still demurred to the accuracy of the drawings in question, and he thought also that the drawings by members of the Jupiter Section exhibited most remarkable discrepancies.

Mr. Chambers, Mr. Wesley, and the *President* all concurred with the writer of the paper as to the desirability of a more general use of a filar micrometer in astronomical drawing.

Mr. E. W. Maunder then showed on the screen and explained a selection of Dr. Roberts's photographic slides of nebulæ, &c.; and *Messrs. Dollond* exhibited a beautifully made position-micrometer, to which was adapted a small electric lamp and pocket-accumulator. The amount of light could be controlled by means of a resistance-coil, and the colour of the light could be regulated by tinted glasses.

The Meeting adjourned at 7 P.M.

What shall we do with our Photographs?

THE great development of activity in astronomical photography which has followed the invention of the dry-plate makes it imperative that the question at the head of this article should be carefully considered at the present time. It is now some years since Prof. Pickering pointed out how serious were the difficulties of merely storing the plates taken at Harvard, owing to the great weight of the accumulation and the necessity of protecting it from fire. Next there are the difficulties of publication, even though this be confined to simple duplication of each plate. In some cases these difficulties are being met by private munificence, as in the case of Mr. McClean's photographs of spectra or of the beautiful volume of photographs just published by Dr. Roberts, to which we refer elsewhere; or by personal enterprise and labour, as in the case of the wonderful series of positives recently sent to the Royal Astronomical Society by Prof. Barnard. This latter course of sending a duplicate photograph to some central institution has much to recommend it: the minimum of labour is thus combined with a considerable probability of usefulness.

But the taking of a photograph and its reproduction or publication have by no means exhausted the possibilities. There still remains *measurement*,—the conversion of the facts revealed by the photograph into numbers which can be compared with the numbers arising from other astronomical methods; and it may fairly be said that the question of the moment is: "What is the method of measurement most suitable for a given photograph?"

It is a question of astronomy and expediency combined; in other words, of essentially *practical* astronomy. In seeking to solve it we must remember not only the facts of astronomy, but those of human life; not only the gigantic periods which measure the movements of the stars, but the few moments available for the continuous work of one man; not only the refinements which can be carried into such work, but the systematic errors which may affect it throughout; not only the immense interest which the smallest portion of the Heavens can arouse, but the vast number of other portions which concentration on the former might lead us to neglect.

There are just two features of a photograph susceptible of measurement: the position of any point and the density of the deposit at that point. An instrument for measuring the former is generally called a micrometer, and for the latter a photometer. We have thus to determine what are the proper forms of micrometer and photometer for a given plate.

From the nature of the case, a final answer to such a question is not to be expected. The most satisfactory process of measurement which could to-day be devised would probably be improved upon to-morrow. But this is no reason for shirking the discussion; rather the contrary, for a better method cannot be propounded until *some* method is conceived. Let me then state here, plainly, that the following suggestions, though the outcome of some experience and discussion, are not tabulated as final, but as a step to something better.

Let us take first the micrometer, and consider how accurately (and therefore laboriously) it is advisable to measure the *positions* of objects on a given photograph. It is here assumed that owing to our limited time and capital we cannot afford to exhaust the possibilities of every photograph,—to measure every object on it as accurately as it can be measured; and, indeed, that a course very far removed from this may be desirable. It may, in fact, not be worth our while to measure a given photograph at all, as in the case of an inferior plate or of a duplicate: or it may be imperative to get the utmost from it that can be got, as in the case of a unique photograph of an important celestial event; and between these extremes range all other degrees of expediency. It would seem tolerably obvious that the amount of labour expended on a photograph should increase as it approaches the condition of being *unique*.

Strictly speaking every photograph is of course unique. The positions of the bodies photographed will never again be exactly the same, not to speak of the climatic and instrumental conditions. But unless a planet or a comet be on the plate, opportunities for taking very nearly similar plates will frequently recur, and thus we may say generally that the photographs worthy of the most elaborate measurement are those of planets and comets. There is, however, another kind of "unique" photograph, viz. one taken with very long exposure, or under conditions not easily repeated; but such are exceptional, and must be treated as special problems.

It is somewhat strange that so little attention has hitherto been paid to the determination of accurate positions of planets and comets by photography. It seems probable that much, if not all, of what Dr. Gill has said of the heliometer as an instrument providing a new astronomical method*, will apply equally to the photographic plate supplemented by the micrometer. If so, the additional advantage of being able to work at leisure in the daytime instead of at night cannot well be over-estimated. Is it that the photographic method is only awaiting trial under the same conditions to which Dr. Gill has subjected the heliometer? He secured the co-operation of a number of observatories in determining the places of stars to be compared with the object observed; but perhaps a slight modification of the programme would evade this labour and yet secure a fair test. We may take as a fair test such a one as Dr. Gill has found to be satisfied by his heliometer observations, viz. that "a minute inequality, which would never have been noticed in even the best meridian observations, was brought to light, and mapped in a diagram so as to be unmistakable."

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* 'Monthly Notices,' Vol. liv. No. 6, April 1894.

It is to be noted that this only tests the measures as *differential* measures, and not as giving an *absolute* place of the planet. So long as the triangulation of the comparison stars is adequate, though their mean position in the sky is not necessarily known with any great accuracy, the path of the planet among them can be determined with such nicety as to reveal the above minute inequality. Will the photographic method do this? A comparatively simple method of attacking this problem would be to change the epoch of observation of the planet from opposition to the stationary point. For several days, or even weeks, a planet may then be photographed on a plate containing the same portion of the sky, and its position among the (same) stars deduced. For the outer planets Neptune and Uranus it may safely be said that such work offers no new difficulties; for Saturn, Mars, and Jupiter it may be that the difficulties of measuring the position of a disk among the stars may be found too great, but this at any rate should not be assumed without trial. For such special and important problems it is right to test the accuracy of the photographic method to its utmost limits, and the labour properly expended on a single plate may become enormous.

As a contrast, let us consider the plates of the Astrographic Chart. Here we have a very large region to be explored under the condition (it surely is an imperative condition?) that all parts should be explored equally. If there is to be uniformity and homogeneity about the work, the total amount of labour available must be impartially distributed over the whole. This condition has been duly regarded in arranging for the taking of the plates; but it seems in danger of being forgotten in arranging for their measurement. It is a natural consequence of the condition that the labour on any one plate must be strictly limited to what can be done within a reasonable time for *all*.

Such self-restraint is always difficult, but it is by no means a new lesson for astronomers. They have already had to learn it as regards the making of observations—they have found by bitter experience that it is fatal to make more observations than they can reduce and publish. Perhaps even yet this lesson is not quite learnt practically, but at any rate the importance of the precept is admitted. Would it not be well, then, to profit by this experience in the new department of astronomy, and apply the precept by abstaining from making elaborate measurements which cannot be extended to the whole area to be covered?

But this point has already been dealt with on several occasions in these columns; and there is no need to further dwell upon it here. It is only again introduced to show why more than one form of micrometer seems to be necessary; why a method of measurement suitable in one case will not do for all; and I proceed now to mention one or two practical details which may commend themselves to general consideration if the validity of the above remarks be admitted.

It is a tolerably simple matter to assign the form of micrometer which will give the most accurate results, labour and time expended being secondary considerations. The positions of the objects must be referred by means of a fine micrometer-screw to the divisions of a standard scale; several bisections of each object must be made; personality and probable error carefully determined; corrections for runs discussed and applied; and so on. All these processes are already familiar to astronomers, and at the present time it is an exercise of ingenuity rather to *avoid* going through all this work than to follow the old lines. The general details of the micrometer, so long as the essential conditions of a standard scale and a micrometer-screw to fill in with are observed, are not important; for though they might lessen the labour expended, this is by hypothesis a secondary consideration.

There is, however, one point worthy of special attention. The scale may either be impressed on the plates as in the Astrographic Chart, or be separately read by another microscope.

The advantages of the former plan are:—

(1) Only one microscope is necessary to read both stars and scale.

(2) Local distortion of the film is to some extent eliminated.

(3) Both coordinates can be measured at the same time.

(4) It is not necessary to make the measures consecutively; for the relative positions of stars and scale are not affected by accidental displacements of the photograph in its frame.

The disadvantages are:—

(1) The additional expense of buying a réseau and printing it on each plate.

(2) The practical difficulties of securing a permanent réseau have not hitherto been satisfactorily solved; those in use develop pinholes, giving false stars. They may require renewing after a time, involving a repetition of disadvantages (1) and (3).

(3) There are two sets of division-errors (in two coordinates) to determine, as well as the *curvatures* of two sets of lines.

The advantages of using a scale separate from the photograph are:—

(1) The method is applicable to many photographs already in

existence on which no réseau has been impressed; and to others on which it may not be considered advisable, or is not possible, to impress a réseau.

(2) The division-errors may be quickly determined, and no question of curvature of many lines is introduced, but that of a single slide. Further, the errors can be reversed by rotating the photograph through 180°; or the zero changed by any arbitrary amount, by displacing the scale longitudinally.

(3) The practical difficulties of making a scale are less than those for a réseau.

The disadvantages are:—

(1) It is generally only possible to measure one coordinate at a time.

(2) No distortion of the film is eliminated.

(3) Two microscopes are necessary, and errors are introduced by any want of rigidity in their connections.

(4) Errors of the slide are introduced.

(5) It is desirable to make the measures as nearly as possible at the same time, to avoid any change of position of the photograph in its frame; or any change in the relative position of the microscopes, as mentioned in (3).

I must confess that to my mind these advantages and disadvantages are very evenly balanced. Advantage no. (1) of the separate scale is of course overwhelming in the case of photographs with no impressed réseau; and hence it would seem necessary to have at least one micrometer with separate scale such as that described by the Astronomer Royal *. But I would suggest the following modification, viz., that the micrometer microscope should read the *scale* and not the photograph. A low power is suitable for the star-images; but a high power may then be used with the micrometer on the scale.

It might be advisable at some time to try a combination of the two forms, by having a separate *réseau* of reference instead of a *scale* of reference. This would combine the advantages and disadvantages above tabulated in a manner which can be readily inferred.

Turning now from the consideration of the most accurate measurement possible to that which may be considered advisable for the plates of the Astrographic Chart, or in other cases where the maximum accuracy is not desirable, I am glad to be able to state that the method of reading by a scale in the microscope eyepiece instead of a micrometer-screw has been found to give satisfactory results. Some months ago I discussed this plan with the Astronomer Royal, and the details were settled in concert with him and with Mr. Simms; and ultimately Mr. Simms has supplied to the Royal Observatory and to the Oxford University Observatory glass scales of the following pattern:—On a circular plate of glass which can be inserted in the focus of the microscope are ruled two scales at right angles divided so that 1 div. = 0·05 mm. on the plate, or 0·01 of a réseau interval. Every fifth division is slightly longer than the others, and every tenth division longer still. The tenth divisions are numbered (starting from one end) 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, (+), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10; so that there are 20 of them altogether, corresponding to two réseau intervals. There is no figure at the point marked (+), which is the point of intersection of the two scales. Now if the plate be moved so that the + is central over a star-image, each scale will cut two réseau lines, and the readings at the réseau lines on each scale will be nearly the same—exactly the same if there is no error of runs. The readings are estimated to tenths of a division—that is, to 0·005 mm. or 0″·3; and readings by different observers do not often differ by more than 0″·6 under satisfactory conditions. The average difference is about 0″·3. Though this accuracy is not quite so great as can be attained with a micrometer-screw, the gain in rapidity is enormous, and a whole plate can be measured in a few hours. It is found possible with very little practice to measure from 40 to 60 images in an hour. H. H. Turner.

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* 'Monthly Notices R. A. S.' vol. liii. p. 326.

[To be continued.]

Potsdam Photometric Observations.

[Continued from page 244.]

The rejection of the plan of determining the differences of the magnitude from one selected star—the plan pursued by Profs. Pritchard and Pickering—has led to the formation of a catalogue of the magnitude of 144 stars, which is probably the most accurate piece of photometric work of this kind yet attempted. The arrangement of these stars is judicious, and likely to be of service in future photometric investigations. They are selected so as to circle the heavens in three zones at declinations of approximately 10°, 30°, and 60°, and are situated at intervals of about 30 minutes in Right Ascension. The magnitudes range from 4½ to 7, and these stars will consequently serve as points of reference down to the eighth or ninth magnitude, without too much trusting to the indications of any photometer. Moreover, being scattered in this way, they will be found at very various altitudes, and over a wide range of latitude help to eliminate the troublesome correction due to atmospheric absorption.

Each of these 144 stars has been compared with six others, viz., the two lying on each side of it in the same zone, and with two others, one brighter and one fainter, in the other zones, care being exercised to make the comparisons at equal zenith distances. In this manner 432 equations of condition result, out of which are to be derived the final magnitudes. Any application of least squares is likely to be attended with greater trouble than advantage, so that a method is employed similar to that adopted by Seidel in the treatment of his measures. Since the equations of condition contain only differences of magnitude, the settlement of the final magnitudes is arbitrary, and a system has been adopted which will ensure the closest agreement with the magnitudes in the 'Durchmusterung.' It is interesting to notice that when the differences of the finally selected magnitudes are taken, there is no discrepancy in the observed differences so great as the tenth of a magnitude. The largest residual is 0·08 mag., and that quantity occurs only four times. The authors have no doubt not overstated their case when they express their conviction that the accuracy of the magnitudes of their fundamental stars is expressed by 0·05 mag., *apart from any eventual correction to their entire system.* In the mean the sixth magnitude of Potsdam coincides with the sixth magnitude of Bonn, but individual differences amount to +0·89 and −0·76 mag., discrepancies which disclose the necessity for a review of the 'Durchmusterung' magnitudes.

Having formed the catalogue of fundamental stars, the way is fully prepared for determining the magnitudes of the selected stars. The plan adopted is to select short zones containing as a rule twelve stars, and these twelve are compared with two of the fundamental stars, at the beginning of the zone, in the middle, and at the end. The consequence of this arrangement is that practically eighteen stars have to be compared with the artificial star of the Zöllner photometer, in order to secure the definite magnitudes of twelve, or the work is increased by one half. The authors maintain that their work is proportionately increased in accuracy. They refer with some severity to the haste that has characterized Prof. Pickering's work, and they point with intense satisfaction to the fact that the theoretical accuracy of a measure in the Harvard Catalogue is 0·15 mag., while in the Potsdam this number falls to 0·057 mag. The probable error of the catalogue magnitude is in the case of the Harvard work ±0·075 mag. and of the Potsdam ±0·040 mag. But the zone catalogue affords abundant evidence that the eye does not appreciate such minute differences of light. Since the comparison stars are observed three times in a zone, usually within a space of time not greater than thirty or forty minutes, we have three separate determinations of the difference of the brilliancy of these stars, and this difference ought to coincide with that found in the catalogue of fundamental stars. This question has of course received attention from the authors, and on page 401 it is stated that the probable error of a single measure of the comparison stars is respectively ±0·065 mag. and ±0·053 mag., according as photometer C or D is used. But one would like to know, as indicating the actual capacity for the appreciation of the equality of two lights, what are the individual errors in the zones themselves. This is not indicated, but is easily deduced, since the logarithms expressing the light of both stars are given. It is suggested that the opinion which anyone would gain from a comparison of these figures is, that the tenth of a magnitude is an unmanageable quantity, for the eye of these acutely trained observers fails to detect it. On a point so important as this, for it really indicates the final accuracy which may be anticipated in the measurement of light by photometers as at present constructed, it will not be misunderstood if this be illustrated by an example. The two stars in the fundamental catalogue, nos. 16 and 18, and which are respectively B.D. +11° No. 1588 and +10° No. 1818, have assigned to them the magnitudes 6·64 and 6·72. And therefore it might be anticipated that in every case No. 16 would be seen brighter than its companion. Yet in the examination of a very few zones, I find no less than five cases in which No. 16 is recorded as the fainter. In the first two zones in which these stars appear, Nos. 84 and 92, the differences of the logarithm of the light is as follows :—

Zone 84.		Zone 92.	
Diff. of log.	Diff. of mag.	Diff. of log.	Diff. of mag.
−·0515	−0·13	+·0048	+0·01
+·0411	+0·10	+·0917	+0·28
+·0123	+0·03	+·0995	+0·25

Here we have a range of four-tenths of a magnitude, and the same amount of error will be repeatedly met with in the observations of the fundamental stars themselves. The instance quoted has been given simply because the stars were nearly of the same magnitude, and therefore discrepancies readily disclosed themselves; but any one may turn through the catalogue and recognize similar variations, and, further, whoever is accustomed to photometric work knows that the most careful research will have in it errors similar to those mentioned here. Attention is not called to these discrepancies in any carping spirit, but with the view to the removal of any misconception that may be formed of the final accuracy to be expected in a photometric catalogue. With these facts before us one might ask whether the authors, profiting as they unconsciously do by the mistakes and the experience of others, are justified in the strictures they have passed upon Professors Pritchard and Pickering. It may be that the catalogue before us is the most accurate piece of photometric work yet recorded, and that it has had lavished upon it the greatest amount of care and attention—the authors have not concealed their opinion of it—but we cannot doubt but that this in its turn will be supplanted by other investigations of the same character in the continual progress towards final accuracy.

Very different and more interesting is the comparison of the photometric work with eye-estimations of magnitude. In a short table, page 487, the authors have given the result of the comparison of their measures with the magnitudes assigned in the 'Durchmusterung.' The result shows that a different scale of magnitude is adopted in assigning numerical magnitudes to the brighter than to the telescopic stars. For stars brighter than the third magnitude there is a difference in the mean of half a magnitude between Potsdam and Bonn, and this difference gradually diminishes to the sixth, when the two scales coincide, and the agreement is as satisfactory as could be wished. This implies that in the brighter stars the light of one magnitude differs from the next by the factor 2·13, instead of 2·512, the coefficient now in general use. This fact had already been pointed out by Lindemann, and the confirmation is satisfactory. In the telescopic stars there is an abrupt return to the ordinary coefficient.

In addition to this comparison with the eye estimations, the authors have instituted a second, with the photometric work of Pickering and Pritchard. It is found that the Potsdam measures include 791 stars in the 'Harvard Photometry,' 801 in the 'Photometric Revision of the Durchmusterung' in the Annals of the Harvard College Observations, and 691 in the 'Uranometria Oxoniensis.' The results of the comparison are set out for every half-magnitude, and are divided according to the observed colour of the stars. The study of the effect of colour on the resulting magnitude is not uninstructive, but we have room only for the results of the entire collation. The red stars are not sufficiently numerous to arrive at a definite result, but there seems to be a marked difference between the white stars and those in which the red colour is more or less salient. The difference is equally noticeable in both the Harvard and Oxford results, but is rather more prominent in the Harvard. When all the stars are compared, without reference to colour, the following results are deduced:—

Star Magnitude.	No. of Stars.	Potsdam —H. P.	No. of Stars.	Potsdam – D. M. Revision, Vol. xxiv. H. A.	No. of Stars.	Potsdam – Pritchard.
		m.		m.		m.
Brighter than 1·50	5	+0·24	1	—0·35	5	+0·19
1·50–1·99	1	0·20	...	...	1	0·27
2·00–2·49	4	0·36	...	...	7	0·50
2·50–2·99	6	0·27	...	...	4	0·24
3·00–3·49	11	0·16	1	+0·33	12	0·22
3·50–3·99	41	0·16	3	0·13	38	0·24
4·00–4·49	54	0·16	4	0·04	47	0·14
4·50–4·99	75	0·13	4	0·08	55	0·08
5·00–5·49	162	0·20	14	0·27	157	0·12
5·50–5·99	253	0·19	72	0·21	195	0·11
6·00–6·49	150	0·13	145	0·16	149	0·11
6·50–6·99	29	+0·13	262	0·13	21	+0·15
7·00–7·49	...	...	205	0·10	...	......
7·50–7·99	...	...	77	+0·06	...	......
8·00–8·50	...	...	13	—0·08	...	......
Sum and Mean.	791	+0·17	801	+0·13	691	+0·13

The limits of magnitude given in the first column do not quite agree with those given on page 494, but no practical error is introduced by the grouping as shown here. There is the further question of the disagreement of individual stars in the three lists, and it appears that, neglecting the constant difference between the several catalogues, 53 stars in Pickering's first catalogue, 27 in his second, and 55 in Pritchard's deviate by half a magnitude or more from the Potsdam results. I do not think that it is mentioned by the authors, but cases will be found in their own observations, when the stars have been observed on more than two nights, in which the deviations between the separate determinations also exceed half a magnitude. Such occasional errors do not greatly deteriorate from the general value of the work, and we may well congratulate Drs. Muller and Kempf on the successful completion of the first portion of their arduous undertaking, and assure them that astronomers will look with interest for the continuation of the photometric 'Durchmusterung.' W. E. P.

Selenographical Notes.

Maurolychus and its surroundings.—This is unquestionably one of the grandest walled-plains on the Moon's visible surface, and when viewed under a low Sun, with Barocius, Stöfler, Faraday, Clairaut, and other massive enclosures in the vicinity, presents a spectacle which is not easily effaced from the mind. Like many of the great irregularly-shaped formations so characteristic of the 4th Quadrant, it impresses one with the idea that we have here the result of the crowding together of a number of rings which, before the surface was perfectly solidified and when they were in a viscous or semifluid condition, interfered with and deformed each other. Maurolychus extends fully 150 miles from west to east, and is enclosed by a rampart rising, according to Schmidt, at one peak on the west, to a height of 18,000 feet. Below the crest of the wall on this side, and on the outer slope, is a fine rill-valley which, though not shown in the maps, is an easy object when the opposite border is on the morning terminator. It runs round the north-west flank of the formation towards the irregular enclosure *d* on the north. The inner slope of the west wall affords one of the best examples of prominent terraces on the Moon, some of them attaining in places an altitude almost equal to that of the crest of the main border. The central mountain, taking Schmidt's measurements, is close upon 4000 feet above the floor, and stands out as a brilliant island of light amid the shadow long before a ray of sunlight has reached the lower terraces. Unlike the great compound mountain masses within Petavius, Gassendi, and other formations, it appears to consist of a single massive cliff of considerable length running obliquely across the floor, a number of much less imposing elevations being associated with its flanks.

I have seen three large craters and several smaller ones in the interior with a 4-in. achromatic. At 9^h on April 4, 1892, I noted, with a power of 284 on a 8½ Calver reflector, twelve on the southern side, but failed to see the rill ϕ, which, according to Neison, runs from a point a little east of the centre to the west side of the incomplete ring *f* associated with the south-east border.

On the previous night at $8^h\ 20^m$, the floor of Barocius being just free from the shadow of its massive west wall, two crater-pits were seen on the eastern side of its dark interior, and an especially good view obtained of a very curious square enclosure extending from the foot of the south wall more than halfway up the slope. Schmidt draws a regular ring in this position, which this object certainly is not.

From the 40th to the 50th parallel south of the equator, and for more than 10° of longitude west of Maurolychus, there is a comparatively undisturbed region, which, with the exception of Nicolai, contains no formation of sufficient prominence to deserve a distinctive name. Yet when observed under a low morning Sun it is seen to abound in objects of a very noteworthy character, consisting of a number of small shallow enclosures, most of them with bright rims and floors, and many of them presenting very irregular and fantastic shapes. On the evening of April 3, 1892, between $8^h\ 20^m$ and 10^h, I observed fifteen of them, varying from about 25 to 5 or 6 miles in diameter, mingled with a countless number of smaller craters and little pits, all situated within 100 miles of the western flanks of Clairaut, Barocius, and Maurolychus. On referring to Schmidt's map, it was found that, with the exception of a few of the larger objects, they are not accurately shown. On subsequent occasions I have bestowed some care in preparing a chart of their position and general appearance, a copy of which I shall be glad to forward to any observer who may be desirous of scrutinizing this very interesting region. Two short clefts were noted in connection with these features—one, just beyond the outer western slope of Barocius, running in a meridional direction, and a second, on the south of it, extending from north-west to south-east. In both cases their terminations are marked by craters. The best phase for observing this neighbourhood is when the west wall of Faraday is on the morning terminator. THOS. GWYN ELGER.

Beaumont House, Shakespeare Road,
Bedford, 1894, July 19.

The Dawn of Astronomy *.

PROF. NORMAN LOCKYER is to be heartily congratulated on the production of his latest book. We scarcely know whether to

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* 'The Dawn of Astronomy: a Study of the Temple-worship and Mythology of the Ancient Egyptians.' By J. Norman Lockyer, C.B., F.R.S. Cassell & Company, 1894. 21s.

admire more the inspiration of happy ideas for the lucid explanation of some abstruse problems in Egyptology, or the masterly process of constructive reasoning by which these ideas are supported.

The book is an exhaustive monograph on the temples which litter the plains of Egypt, and which have formed the subject of much research during the present century. It specially treats of their orientation, a subject which, as the author explains in his preface, has previously been discussed by Prof. Nissen, of Germany. Most of these buildings, we might say all of them, are similar in one respect; the chief feature of each is a central passage, in some cases as much as a quarter of a mile long, the exterior opening being flanked on either side by massive pylons, bearing some likeness to the two towers on the western face of our modern cathedrals, and intercepted at different points of its length by smaller pylons or buttresses, always leaving a clear passage to an inmost sanctuary, closed by a wall on the side opposite the entrance. But these temples, while thus alike, are different in this respect, that the azimuth of the central passage is widely different in different buildings, a difference which has hitherto been ascribed simply to Egyptian symmetrophobia. It is this want of symmetry that Prof. Lockyer now undertakes to explain.

The keystone of the theory is that these central passages are really horizontal telescope-tubes, the interior buttresses performing the function of the stops in a modern telescope, ensuring that the light from a celestial object entering the aperture may pass pure, without intermingling with light reflected from the side walls, to the eyepiece, represented in this case by the inner chamber.

This theory obviously demands that each temple should have been set up to observe some single definite object; and with great ingenuity the author has assigned to each temple the object for observation of which it was built, classifies the buildings, and connects the classification with a homogeneous system of religion and chronology.

Let us follow Prof. Lockyer in his first division of the buildings, into solar temples and stellar temples. It is trite to say that the first object of astronomical observation with a primitive people would be the Sun—first as an object of wonder and worship, and second as an object which might be used for setting the calendar. Many most interesting pages of the book are devoted to showing that the Egyptian pantheon was solar in origin, that our luminary was worshipped under many names and in many stages of his daily and annual course—one deity, Harpocrates, representing the rising Sun, another, Rā, the noontide Sun, and others representing the Sun at different times of the year, Rā being the generic name; and when Mr. Lockyer tells us that the axes of many temples are so placed that the Sun rising at the summer solstice or the equinox shone along the central passage, it seems reasonable to suppose with him that the temple was placed with a double purpose in view—first, for a religious ceremonial, such as the Manifestation of Rā, in which the Holy of Holies, or possibly an image placed therein, was lit up for a few moments, to enable a jealous priesthood to trade upon superstitious ignorance; and secondly, for the same priesthood to obtain an accurate time-observation for the setting of their calendar.

Assuming this origin for a temple, the change of declination at the solstice due to change of obliquity of the ecliptic, and the consequent change of amplitude at rising, the axis would not fulfil its purpose through a very long period of time. A careful study of the temple of Amen-Rā at Karnak has led to the conclusion that the building has been altered since its original foundation so as to alter the azimuth of the axis by about one degree; and from measurements, in which he was helped by officers of the Public Works Department in Egypt, Mr. Lockyer concludes, although with some doubt, that this temple was founded about the year 3700 B.C. for the purpose of observing the setting Sun at the summer solstice, and that the direction of the axis was altered at a later date to correspond to the change in the obliquity of the ecliptic during the interval.

Turning now to the other class, the stellar temples, built on a plan similar to the former class, but whose axes have such direction that they could never point to the Sun, we have some literary evidence that in the founding of temples the positions of stars were consulted, and that starlight was used in ceremonials similar to that referred to above. Referring to the temple of Tyre, Prof. Lockyer says:—"According to Herodotus, in the temple in question there were two pillars, the one of pure gold, and the other of an emerald stone of such size as to shine by night. Now there can be little doubt that in the darkened sanctuary of an Egyptian temple the light of α Lyræ, one of the brightest stars in the northern heavens, rising in the clear air of Egypt would be quite strong enough to throw into an apparent glow such highly-reflecting surfaces as those to which Herodotus refers;" and again in the translation of two inscriptions which describe the alignment of the temples at Denderah and Edfû the stars used in directing the building line are absolutely named, although it must be added that there is considerable doubt whether the line thus denoted would point to a *rising* star.

But the general assumption is that the temples were so laid that the axis might point to a star rising heliacally, that is, a little before the Sun, possibly to give a warning for making the arrangements for the ceremonial to be held at sunrise. This view is strongly supported by the arrangement of the temples dedicated to Hathor and Isis at Denderah. Taking the dates for the foundation of these temples as given by Mariette, we find that in 700 B.C. the axis of the temple of Isis (which, there is good reason for thinking, is a name for the deity equivalent to the star Sirius) pointed to that star at its rising, that the larger temple of Hathor pointed to the rising Sun at the summer solstice (the Egyptian new year's day) at the same date, and, finally, that the star Sirius rose with the Sun at that epoch. These circumstances are detailed in an inscription found at Denderah, and translated by Mariette:

> "She [*i. e.* her Majesty Isis] shines into her temple on New Year's Day, and she mingles her light with that of her father Rā on the horizon."

A change in the line of observation, such as that referred to in the case of solar temples on account of the change of obliquity of the ecliptic, would obviously be more necessary in the case of a stellar temple on account of precession, which changes the declination of a star comparatively rapidly, and which would alter the amplitude by 1° in about 300 years. Mr. Lockyer sees in this a cause for the existence of two temples quite close together at Medînet-Habû, whose axes are inclined at a small angle, and also for a similar fact at the Parthenon at Athens, where are two buildings with slightly different orientation side by side. The assumption is that in these cases a new edifice was built instead of changing the axis of the original.

We have not space here, much as we should like, to follow Prof. Lockyer through his exhaustive researches on the rise and fall of the Nile and its connection with the Egyptian calendar. Suffice it to say that the beginning of the annual rise of the river took place at the summer solstice, which was the new year's day, that this phenomenon was intimately connected with the social life of the people, and that the river was worshipped as a god. But there were other rivers which were equally important to the inhabitants of the surrounding districts. What the Nile was to Egypt the Euphrates and Tigris were to a large region of Western Asia, where the annual flood was a source of fertility and the rivers were worshipped as gods in order that their benign influence might be secured. This fact leads to a classification and explanation. The Euphrates and Tigris rose at the spring equinox, and the religion of the Babylonians was therefore equinoctial: the conclusion is that the temples oriented respectively to the equinoctial and the solstitial Sun were built by two races of people—the one coming from the region of Mesopotamia and bringing their religion with them, the other a race of people indigenous to Egypt. Further, a classification of the stellar temples shows that the religions of these two peoples were connected with two sets of stars—the deified stars of the early inhabitants of Northern Egypt, whose civilization we glimpse, being α Ursæ Majoris, γ Draconis, and Capella; whilst the Southern stars, of which Phact and Sirius are typical, were worshipped by an invading race, and who possibly were the pyramid-builders, coming up the Nile from the South.

In the above mere sketch of the plot of this delightful book many interesting details are necessarily not touched on. We might glance at the Egyptian symbols representing astronomical facts, such as the representation of the Sky by a female figure, Nu, bending over Seb, the Earth, with feet on one horizon and finger-tips on the other, the varying lengths of the paths of two stars of different declination being represented by two such figures one over the other. At the astronomical explanations of the myths of Egypt, such as that of Horus, who is said to have killed a crocodile or hippopotamus; in later times the myth states that the creature destroyed was the Thigh of Set (the Great Bear). The interpretation of this given by Prof. Lockyer is simply that Horus (the rising Sun) extinguishes the circumpolar stars, which at the time of the earlier myth were the stars of the Dragon or Crocodile (called a hippopotamus by a people to whom the crocodile was sacred), and at the time of the later form of the myth the stars not setting would be those of Ursæ Major. There is also in the chapter on the calendar a suggested explanation of the abnormal age to which Methuselah and other biblical personages are said to have attained, namely that in one form of calendar a lunar month was called a year; and taking this as the bible unit it is apparent that Methuselah was not a particularly old man. In conclusion we can only hint at Prof. Lockyer's suggestions how the orienting of Egyptian temples and their arrangement had their effect on Greek architecture, and that the idea of planning a building in honour of a patron saint has survived even to comparatively recent times in our own country, where the eastern window of a church was often placed so that the rising Sun should shine through it on the morning of the day of the saint to whom the fane was dedicated.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Proper Motion of B.A.C. 793.

GENTLEMEN,—

In 'Monthly Notices,' vol. xxxv. p. 356 (May 1875) Prof. Piazzi Smyth contributed a paper on the proper motion of the star in Cetus numbered 793 in the B.A.C. and II. 123 in Piazzi's Catalogue, in which he suggested that the proper motion was variable, and had sensibly diminished in R.A. and increased in N.P.D. In a paper immediately following this, Mr. Dunkin showed, from a discussion of the Greenwich observations, that there was little real evidence of any change in either element. He recurred to the subject in vol. xxxvi. p. 254, availing himself of more recent Greenwich observations, and came to the conclusion that "the proper motion of B.A.C. 793 has not really changed during the present century." Mr. Stone (in a short paper which follows Mr. Dunkin's) pointed out that the Cape observations of the star in R.A. (none were available in N.P.D.) did not appear to give any evidence of change of proper motion. In the Greenwich Nine-Year Catalogue for 1872 the proper motion used is derived from Mr. Dunkin's second paper and amounts to $+0''\cdot 120$ in R.A. and $-1''\cdot 50$ in N.P.D. (These are slightly altered in the Ten-Year Catalogue to $+0''\cdot 1245$ in R.A. and $-1''\cdot 456$ in N.P.D.) It occurred to me that it might be worth while to compare the places given in the Nine-Year and in the Ten-Year Catalogues, especially as the former contains 13 observations in R.A. and 14 in N.P.D., and the latter 13 observations in R.A. and 12 in N.P.D. Now the place from the first (for 1872) is R.A. $2^h\ 29^m\ 3^s\cdot 818$, N.P.D. $83^\circ\ 43'\ 31''\cdot 02$. The mean annual precession is $+3^s\cdot 1616$ in R.A. and $-15''\cdot 949$ in N.P.D. Multiplying these by 8 and applying them to the above places, we obtain R.A. $2^h\ 29^m\ 29^s\cdot 111$ and N.P.D. $83^\circ\ 41'\ 23''\cdot 43$ for 1880. The place for that year in the Ten-Year Catalogue is R.A. $2^h\ 29^m\ 30^s\cdot 084$ and N.P.D. $83^\circ\ 41'\ 13''\cdot 12$. The differences are $+0^s\cdot 973$ and $-10''\cdot 31$ respectively, giving for the annual proper motion $+0^s\cdot 1216$ in R.A. and $-1''\cdot 289$ in N.P.D. In the former element this does not differ sensibly from the quantity used; but the proper motion in N.P.D. is nearly $0''\cdot 2$ smaller and is almost identical with that given in the B.A.C., which is $-1''\cdot 31$.

It would appear therefore that the question of the exact proper motion of this star is not yet finally settled. I may add that there are no Greenwich observations later than those included in the Ten-Year Catalogue accessible to me, though I have looked through the volumes up to 1890, the last published.

Yours faithfully,

Blackheath, 1894, June 20. W. T. Lynn.

The Comet of A.D. 1630.

Gentlemen,—

In 'Astronomische Nachrichten,' vol. xii. p. 215, reference is made to two comets which are mentioned in a romance of Manzoni ('Promessi Sposi') as having appeared in the years 1628 and 1630 (the latter in the month of June), but of which "sonst keine Nachricht vorkommt." The authority given in the romance is that of Ripamonti, of Milan (who died in 1641); and as the editor of the Ast. Nach. had not access to his works, he wrote to Plana at Turin, who in his answer enclosed a letter from Abbot Assi, stating that it was in his book "De peste quæ fuit anno 1630" that Ripamonti mentioned the comets, which were both "horrifica specie," the second appearing in the very year of the pestilence.

With regard to the comet of 1628, I know of no other allusion to it; but that of 1630 is mentioned in English history as having appeared at the time of the birth of Charles II. Perintheif (quoted by William Harris in his 'Historical and Critical Account of the Life of Charles the Second') says that the Prince's birth "was so great a matter of rejoicing to the people of uncorrupted minds that Heaven seemed also concerned in the exultation, kindling another fire more than ordinary, making a star to be seen the same day at noon." The poet Waller, who was equally ready to flatter either Protector or King, Oliver or Charles, also refers to this comet in his poem "On St. James's Park, as lately improved by his Majesty," near the end of which are the lines:—

"His thoughts rise higher, when he does reflect
On what the world may from that star expect,
Which at his birth appeared, to let us see
Day, for his sake, could with the night agree!
A Prince on whom such diff'rent lights did smile,
Born the divided world to reconcile!"

If the comet in question was really visible at noon, it must have been a very fine one, and doubtless justified Ripamonti's description (applied also to the other of two years before) that it was "horrifica specie." But in that case it is remarkable that no other accounts of it seem to be known. Pingré does not mention either comet. Mr. Chambers gives only the above reference to the 'Astronomische Nachrichten.'

Yours faithfully,

Blackheath, 1894, June 5. W. T. Lynn.

P.S.—Since writing the above, I have had an opportunity of consulting Ripamonti's book 'De peste.' The passage quoted by Assi is in p. 273; but the comets are also mentioned in pp. 110, 111. That of 1630 ("crinitam eam stellam," as it is called) is stated to have appeared in the month of June, and to have been "truci ultra solitum etiam facie." Manzoni therefore quotes the date correctly, which agrees sufficiently with that of the object said to have been seen in England on the 29th of May, which was the birthday of Charles II.—W. T. L.

OBSERVATORIES.

Royal Observatory, Cape of Good Hope.—The Secretary of the Admiralty has recently distributed copies of the Report made to him by Dr. Gill of the work done at the Cape Observatory during the ten years from his accession to the Directorship in May 1879 to July 1889. Most of the subjects spoken of in this Report are now comparatively ancient history. It will be sufficient here to give a list of the results achieved during the period. The average annual number of transits with the transit-circle was 4537, of zenith-distances 3758, and of occultations of stars by the Moon the average is 30 per year. There is a very fine series of comet-observations. Dr. Gill says that "on no occasion have observations of any visible comet been omitted unless observations of it could be made more favourably in the northern hemisphere." Other meridian work consists of determinations of stellar parallax from observations with the 4-inch heliometer, the observations of Victoria, Sappho, and Iris with the 7-inch heliometer for determination of the solar parallax, the results of which will shortly be published, and the making of the Photographic Southern Durchmusterung. The staff of the Observatory has co-operated largely in the Longitude operations connected with the Geodetic Survey of South Africa, and have also determined the longitude, Cape—Aden, *viâ* Natal.

At the date of the Report the reduction of the meridian observations was considerably in arrear, owing to the inadequacy of the computing staff, which has since been strengthened.

Paris.—In the annual reports of national observatories there is always much that is important because it is not new. It is of the first importance to know that the work has been efficiently and continuously carried on on the old lines, and that a homogeneous mass of facts is thus slowly growing in volume with the lapse of time. And M. Tisserand's report for 1893 is eminently satisfactory in this respect. It is clear therefrom that no relaxation of any kind—in quality or quantity of the work—has followed the appointment of the new Director. The printing of the great Paris Catalogue is proceeding with due celerity; more than 17,000 meridian observations were made in 1893; and the watch on instrumental constants, such as those of flexure, has been unremitting.

But though all such work is of the first importance, the details are perhaps only interesting to those engaged in similar work. The average reader will turn more readily to what is new in the report—to the evidences that, with all this care for the routine work, there is life and enterprise in the observatory; and he will probably mark one or two passages, of which the following are brief notes.

A special research on fundamental stars gives corrections to R.A. as below for a few stars (three have been selected at random):—

	1890.	1891.	1892.
θ Virginis ……	$+0^{\mathrm{s}}{\cdot}03$	$+0^{\mathrm{s}}{\cdot}03$	$+0^{\mathrm{s}}{\cdot}02$
25 Canum Ven…	$-0\cdot03$	$-0\cdot12$	$-0\cdot14$
Arcturus ……	$+0\cdot07$	$+0\cdot05$	$+0\cdot04$

The large equatorial coudé has been tried for photography (with a special objective). There are difficulties in grinding, but some fine photographs of the Moon have been obtained. We are reminded by the size of these pictures (7 inches diameter for the Moon) of the great focal length of this instrument.

M. Bigourdan went to Senegal to observe the eclipse of 1893, April, determined his position, made meteorological observations, found the value of gravity by Commandant Defforges' pendulums, and observed the four contacts, but did not find any intra-Mercurial planets.

The brothers Henry are taking ecliptic charts of 8° square by means of a photographic objective of 6½ inches aperture and 40 inches focus, mounted on the astrographic equatorial. The images are round up to the edge of the plates. Of catalogue plates 169 have been taken.

During the year Mdlle. Klumpke and four ladies, with two measuring-machines, have measured 72 plates with admirable completeness. This is a resolute attack on the measurement of the plates, but, alas! it brings with it a corresponding discouragement. If a Bureau des Mésures, certainly twice as well equipped and organized as most observatories can afford, measures 72 plates a year, how long will it take for the average observatory to measure about 1200 plates? It is not the place here, however, to dwell on this point. We should rather mention that in all 27,750 measures were made, 26,831 being of single stars, 343 of double stars, 32 of planets, and 544 being practice measures. Mdlle. Klumpke and her assistants must have worked untiringly.

Yale Observatory.—From the Report just received we learn that Dr. Elkin has made a new series of observations with the heliometer for parallaxes of Capella, Procyon, and Altair, bringing the whole number of series secured for the ten first-magnitude stars to 54. Dr. Chase has also obtained measures of 24 stars with large proper motion, and a series of observations on Algol and β Cygni.

Dr. Elkin gives a revised value of the Sun's parallax as deduced from observations of Iris made with the heliometers at the Cape, Leipzig, Oxford, and Yale:—

$$\pi = 8''{\cdot}825 \pm 0''{\cdot}008.$$

Some time has also been spent on experiments with reference to the photography of meteor-trails. An experimental apparatus has been made of a 6-inch portrait-lens mounted on an equatorial stand with a guiding telescope. Four nights' work with this, fourteen hours in all, two of which were cloudy, gave as result the photographs of six trails. This result has justified the National Academy in voting two thousand dollars to construct a mounting to carry a number of cameras, in the expectation that with a larger field exposed a sufficient number of tracks would be secured to afford reliable data for determination of radiant-points. It is hoped that this instrument will be finished in time for the August meteors of this year.

Hong Kong.—The annual volume of observations and researches made at this meteorological station increases uniformly in bulk and must contain an enormous amount of valuable information for the shipping in the China Seas. We are sorry that Dr. Doberck can apparently afford no time for astronomical work. The present volume contains the Annual Report for

1893, from which we gather that the amount of data gleaned from various ships has largely increased, and that the Director is more satisfied with the general condition of the station than in his recent reports. We notice, too, that two lectures on Typhoons have been given before the British Mercantile Marine Officers' Association of Hong Kong. As appendices to the usual magnetic and meteorological observations we notice:—

Appendix A. Information issued in 1893 concerning Typhoons.
Appendix B. The Climate of Hong Kong investigated from ten years' Observations.
Appendix C. The Typhoons of 1888.
Appendix D. The Typhoons of 1889.

PUBLICATIONS.

GESCHICHTE DER BAHNBESTIMMUNG VON PLANETEN UND KOMETEN. Theil ii. Von Dr. NORBERT HERZ.—The first volume of this history, which was published some time ago, gave an explanation of the astronomical methods of antiquity, of Eudoxus, Hipparchus, Ptolemy, and others. The second volume, now published, gives a view of the theoretical astronomy of the middle ages and the empirical methods in vogue up to the time of Newton. The period of analytical methods inaugurated by Newton's discovery of universal gravitation, and rendered possible by the introduction and application of the infinitesimal calculus, is reserved for a third volume. Before Tycho theoretical astronomy mainly consisted of disquisitions on the motions of the Moon and the five primary planets, and the history of astronomy differs little from a history of the knowledge of planetary motion; but since Tycho the circumstances have changed and these planetary theories form only a part of astronomy. In this history therefore for the period before Tycho the author is concerned with the theory of planetary motion, the theories of Copernicus, Tycho Brahe, and Kepler are exhaustively explained, extracts from the most important works are given to give an idea not only of the results but also of the methods of these investigators, and to this end the mathematical developments are freely included.

The chapters divide the history into periods: in the first we have the continuation of the methods of Ptolemy, as treated in the works of Alfragan and Albateginus, an explanation of the "Trepidation of the Arabians," the Astronomical Tables of Alphonso X. with the explanations of Purbach in his 'Theoricæ novæ planetarum,' and some brief remarks about the state of Persian and Chinese knowledge at this time.

The time of Copernicus brought with it a radical change in astronomical opinion. The exposition of his work 'De revolutionibus orbium cœlestium' is given in great extension in the second chapter, and with it the Copernican theory of the planets and the methods of finding the elements of their orbits and the construction of tables, which does not differ much from that of the preceding period.

In the third chapter the author gives the investigations of Tycho Brahe, Rothman, Galileo, beginning with a criticism of Tycho's opinions of the Copernican system, and the causes which led Tycho to adopt a new one. The author's opinion is that Tycho was really convinced of the truth of the Copernican system, but that prudence compelled him to evolve his own: some evidence is adduced in support of this view, remarkably Tycho's computation of the orbit of the comet of 1577, which is given in some extension. This chapter contains explanation of some important discoveries in the Lunar Theory, the Variation, Annual Equation, and the Perturbation in Latitude.

With the epoch of Galileo and the invention of the telescope the history of astronomy divides into two branches, theoretical and practical. This work is not concerned with the latter of these two branches, except in a brief notice of Galileo's merits as a mechanician.

The next section is devoted with great detail to Kepler and his works. Beginning with his first investigations as to the connexion between distances and periodic times published in the 'Mysterium Cosmographicum,' the author gives extracts from several of Kepler's works and essays, many of which led to no result, but bear witness to the great sagacity and penetration of that great man: notably we have an extract from Kepler's great work 'De stello Martis,' which gives his methods of finding the ratio of the distances between the Sun, the Earth, and Mars, and hence the orbits of the two latter bodies. The chapter ends with Kepler's theory of comets and an explanation of his method of finding the elements of their orbits.

The remainder of the volume contains brief reviews of miscellaneous works on theoretical astronomy up to the time of Newton; the works of Lansberg and Riccioli, who reverted to the theory of Epicycles, the elliptic theory of Fabricius, the investigations of Bullialdus, Cassini, Halley, Lahire, on the positions of the aphelia, and Halley's researches on the motions of Saturn's satellites, are dealt with in turn; and the book concludes with a review of researches on comets by various authors, including an extract from a rare essay by Doerfel, who discovered a parabolic orbit for the comet of 1680.

ROBERTS'S PHOTOGRAPHS *.—It would indeed have been an ungracious task to criticize the splendid volume before us,

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* 'A Selection of Photographs of Stars, Star Clusters, and Nebulæ, together with information concerning the instruments and the methods employed in the pursuit of Celestial Photography.' By Isaac Roberts, D.Sc., F.R.S. London: the Universal Press, 326 High Holborn, W.C. The Collotype plates by the Direct Photo-Engraving Co., Barnsbury.

could we have found sufficient reason. It is a published work, offered to the astronomical public, which we hope that public will enthusiastically purchase; but it is at the same time a free gift, for time, labour, and expense have been lavished upon it without any thought or prospect of return. It contains reproductions, by an admirable process and on a large scale, of 51 of Dr. Roberts's well-known photographs, representing a total actual exposure of 110 hours, or more than 2 hours per picture; indeed 7 of the plates have been exposed for 4 hours, and 5 others for 3½ hours. The reproductions usually measure 10 inches by 8, and represent on the scale generally adopted about 100′ by 80′ (1 mm. $=24''$, or 1 inch $=10'\cdot15$). These fifty portions of the sky may thus be quietly studied "at all times,. . . . as they would appear to an observer aided by a powerful telescope and clear sky for observing."

In a brief Introduction are given descriptions of the methods of work, with photographs of the observatory and the instrument. The latter is a reflector of 20 inches aperture and 98 inches focal length. A guiding telescope of 7 inches aperture is attached to the other end of the declination axis, but can move independently in declination. This independence is in some ways an obvious gain, but for the direct purpose of a guiding telescope it introduces difficulties owing to the want of rigidity in the connection; and to meet these Dr. Roberts uses a collimating telescope. This is a small telescope attached to the back of the mirror and pointing through a central hole in it to the plate-carrier. On the back of the shutter of the carrier is a small silvered glass plane, which will reflect a star-image (when the shutter is closed) to the cross wires of the collimating telescope. When the star is bisected by these cross wires it is brought also to the cross wires of the guiding telescope, which is then in adjustment with the reflector. During long exposures this adjustment must be repeated at intervals, owing to the want of rigid connection mentioned above. This is a very ingenious arrangement, but does it not almost suggest that the guiding telescope is not wanted? If such an arrangement is accurate enough to adjust the guiding telescope at intervals it is surely good enough to guide with itself? True, in the present form the shutter must be closed to see the guiding star, which is near the centre of the field; but if the reflecting plane were attached excentrically, where the images are still not too bad for bisection, it might be left permanently in place.

Though it seems ungrateful to say so, we could have wished for more of the Introduction: take, for instance, the interesting question of the diffraction rays in the images of bright stars. We are told that these are due to the bars supporting the plate-carrier; but no description or diagram of these bars is given. There are four bold rays at the quadrants which suggest a four-bar support for the plate; but there are other minor rays symmetrically distributed, and of much the same form in Plate 4 (taken in 1890, at Dec. 60° N.) as in Plate 11 (taken in 1888 at Dec. 24° N.); and details concerning the support of the plate-holder might have thrown some light on the origin of these minor rays.

Coming to the photographs themselves, they are arranged in the convenient order of right ascension, and facing each is an admirable summary of relevant information. The scale and orientation of the photograph are shown with all requisite accuracy and convenience by the tabulation of the R.A. and Dec. for 1900·0 of four "fiducial stars" which are marked on the plate by minute dots. The question of the accuracy and uniformity of the scale is of the first importance; and Dr. Roberts has done his best to correct errors of scale introduced by the collotype processes of reproduction by tabulating in the Introduction the accurate scale for each photograph. It is doubtful, however, whether these errors are the same for all copies. Take, for instance, the three plates of the Orion nebula, Nos. 15, 16, and 17: in the table Dr. Roberts gives the value of 1^{mm} for these plates as $23''\cdot79$, $24''\cdot22$, and $24''\cdot24$ respectively; so that we should expect a distance between two stars on plate 15 to be about $\frac{1}{50}$ larger than the corresponding distances on plates 16 and 17, which should be sensibly equal. On applying a pair of dividers to the fiducial stars in the copy before us, however, we find the scale of plate 17 to be about intermediate between those of plates 15 and 16, though the relation indicated between the scales of 15 and 16 is confirmed. But allowing for this change of scale value, the collotype process seems to give a sensibly faithful reproduction, so far as available tests can show. The study of such points, however, must be made much more elaborately; and it is only by careful study of a special point that the true value of these charts can be demonstrated. Dr. Roberts has mentioned "some of the uses to which the printed charts will be applied, viz.:

"1. The detection of changes in the structure of nebulæ.
"2. The detection, on a large scale, of movements amongst the stars.
"3. Determinations of variations in stellar magnitudes.
"4. Relative distribution of the stars in space.
"5. Detection of new stars and disappearance of others."

But it seems to us probable that the real usefulness of these charts is as yet unknown, and will only be discovered by working at them diligently.

THE GREENWICH PUBLICATIONS FOR 1891.—The Astronomer Royal has recently issued the books giving the results of the work of the Royal Observatory during the year 1891. The issue is rather late compared with that of previous years, owing to causes outside of the control of the Astronomer Royal, which were explained by him in his recent Report to the Board of Visitors. The matter contained in the volumes is of the usual form, giving original observations made in the various departments with the deduced results. The number of observations made with the transit-circle is rather below the average of recent years, owing to the fact that the object-glass of the instrument was dismounted for cleaning during two months of the year. At the same time a new system of wires was adapted to the eyepiece and new screws were furnished to the telescope micrometer.

There is an appendix to the volume, also issued as a separate book, which is rather a novel feature. This is a catalogue of 258 fundamental stars deduced from observations made in the years 1887–91, and reduced to the epoch 1890·0. The places in the catalogue depend mainly on observations made in these years, but in a few cases, where less than ten observations have been obtained, the catalogue place depends on a combination of the place in the Ten-year Catalogue (epoch 1880·0) reduced to 1890·0 and the later observations. For this reason the Ten-year Catalogue places reduced to 1890·0 are given in parallel columns with those of the catalogue now before us, which affords at a glance a valuable check on the character of the systematic differences between the catalogues. The errors in the assumed relative places of the clock-stars originally derived from Pond's Catalogue, on which these catalogues depend, are now very small, but the corrections to be applied to the clock-star places deduced from observations of the Sun to give their absolute right ascension, as explained in a note in our last number, is a comparatively large quantity in the years 1887–91, the average of the five years being $+0^s{\cdot}043$. This correction has not been applied, as its validity did not appear to be sufficiently well established, bearing in mind an investigation treating of the effect of personality on this quantity lately published in the 'Monthly Notices.' The zero of Right Ascension of this catalogue is therefore the same as that of the 1880 catalogue, and of the Greenwich clock-star lists.

The catalogue is in the well-known form of previous Greenwich catalogues (with the addition of the double columns referred to above), the values of the annular precession and secular variation for the epoch being given for each star and the proper motion, taken generally from Prof. Auwers' 'Neue Reduction der Bradleyschen Beobachtungen' or his 'Catalog der Fundamental Sterne.'

ELEMENTS OF ORBITS OF COMETS.—We have received a most invaluable book* from Dr. J. G. Galle, of Breslau. This gives, first, a list of all known comets with the elements of their orbits from the year 372 B.C. to the end of 1893 A.D., and, secondly, literary notes on each comet, giving the name of the discoverer, in some cases those of other observers, and references to the literature about the object. The utility of this work is obvious; it should find a place in every astronomical library.

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* 'Verzeichniss der Elemente der bisher berechneten Cometenbahnen.' Leipzig, 1894.

PUBLICATIONS OF THE HYDROGRAPHIC OFFICE.—There are many pamphlets and books issued by our Hydrographic Office which are too little known. Being careful compilations of information from every available source these pamphlets are of special value, as containing information only derivable from the special expeditions of the Hydrographic Office. Just now the collecting of information respecting the positions selected for observing the Total Solar Eclipse of 1896 is engaging the Eclipse Committee of the R.A.S. and others, who will find one of these books of service. The climatic and other peculiarities of Norway stations seem pretty well known, and for information on the Japan stations we refer to the 'China Sea Directory,' vol. iv. 3rd edition, 1894*. This is a good sized volume. The three pamphlets just come to our notice are:—'List of Time Signals in various parts of the World'†; Appendix to same‡; 'Table of Longitudes accepted for Secondary Meridians'§.

PUBLICATION DER CHARKOWER UNIVERSITÄTSSTERNWARTE.—The second volume of these publications contains an account of the determination of the difference of longitude between Nicolagen and Charkow, and a daily register of sun-spots in 1893. These are in German; the remaining portion of the work being printed in Russian character does not commend itself to notice.

NOTES.

COMET NOTES.—Gale's Comet, which has gradually been getting fainter, is now probably beyond the range of even the largest telescope. Observations of its position were made with the 28-inch refractor at Greenwich on July 11, and this is the latest observation to hand. The following letter, with reference to this comet, has been received:—

Private Observatory,
Windsor, New South Wales,
1894, June 17.

GENTLEMEN,—

In the conversion of my original telegram into cypher at Melbourne for transmission to Kiel, it appears that the date of discovery of this comet (April 1) was omitted, and so a general misapprehension was created as to the date. I have no doubt that the published reports from Australia have already removed this misapprehension. The observations at my observatory extend from April 3 to May 11. Adopting the observations on the extreme dates, and the early observations for April 22, I obtain the following positions referred to the ecliptic and to the mean equinox of 1894·0, the times being corrected for aberration and the places for parallax:—

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* Price 3*s*. 6*d*. † 1*s*. ‡ 6*d*. § 3*d*.

Greenwich Mean Time.	λ.	β.
d	° ′ ″	° ′ ″
April 2·93926	358 33 0·1	−63 25 27·3
21·87188	79 45 59·6	−69 6 18·7
May 10·86205	138 29 41·3	+ 1 46 48·5

The two extreme places are satisfied by the following system of elements:—

$T = 1894$, April $13^{d}\cdot51310$ Greenwich M.T.

$$\left.\begin{array}{ll} \omega \ldots\ldots & 324^{\circ}\ 17'\ 8''\cdot 6 \\ \Omega \ldots\ldots & 206\ \ 20\ \ 56\ \cdot 5 \\ i \ldots\ldots & 87\ \ \ 4\ \ \ 6\ \cdot 2 \end{array}\right\}\text{ M. Equinox } 1894\cdot 0.$$

$\log q$ .. 9·99927265.

And the middle place thus:—

Obs.—Cal. $\Delta\lambda \cos\beta = +13''\cdot 2$, $\Delta\beta = -16''\cdot 1$.

The orbit is probably elliptic. The comet passed its ascending node on May $10^{d}\cdot2354$ G.M.T., at a distance of 0·0814 outside the Earth's orbit. Had it reached this point twenty-four days earlier, it would doubtless have been a fine object. John Tebbutt.

In continuation of his investigation of the variation of latitude by help of Pond's double-altitude observations, already noticed in previous numbers, Mr. Chandler has treated the mural-circle observations made at Greenwich under Airy from 1836–1851 by the same method. When Airy assumed the directorship of the Royal Observatory he continued for a few years the method of double-altitude observations established by Pond (*vide* p. 149, vol. id.); but in February 1839 he gave up the Jones circle, which was sent to the Cape, and inaugurated the method, in use at the present day, of observing stars with the Troughton circle by reflection and direct observation at the same culmination. The Troughton circle was dismounted in May 1848, to make way for the present transit-circle, during the installation of which the Jones circle was used in another building. The published results of these three series of observations of stars by reflection, which give the north polar distance of stars free from index error, have been corrected by Mr. Chandler, to show them as if reduced with Peters' constants of precession and nutation, constant of aberration 20″·500, Boss's proper motions, with latitude 51° 28′ 39″·00, and to the beginning of Bessel's fictitious year 1830, which were the constants adopted in his previous investigation of Pond's observations. The polar distances thus corrected have been then treated by the method described in our June number, p. 212, and the resulting formula for the latitude variation thus evolved from the whole series is

$$\phi-\phi_0 = -0''\cdot060 \cos(t-2393712^{d}\cdot5)\,0^{\circ}\cdot84$$
$$-0''\cdot138 \cos(\odot-355^{\circ}\cdot3).$$

Comparing the epoch of the first perodic term in this formula with the value of the same quantity as found from Pond's observations, we have the value of the period $422^{d}\cdot7 \pm 1^{d}\cdot9$. "The mean value which satisfies the observations over an interval of nearly one hundred and seventy years is $428^{d}\cdot6 \pm 0^{d}\cdot2$. The difference of these values is about three times its probable error. Taken by itself this fact would perhaps not be sufficient to demonstrate an actual departure from the mean value of the period. But it appears to be corroborated by the Pulkova observations, 1840-44. There is similar reason for presumption that the amplitude of this term of the variation suffered material diminution near 1840. Corresponding variations are perceptible in the constants of the annual term."

In the 'Astronomical Journal,' No. 322, Mr. Chandler begins a fresh stage of his investigation. He now proceeds to collect results. It will doubtless be remembered that, according to him, the variation of latitude of a place in longitude λ, whose mean latitude is ϕ, at time t (reckoned in Julian days), can be represented by a formula

$$\phi-\phi_0 = -r_1 \cos[\lambda+(t-T_1)\theta] - r_2 \cos(\lambda+\odot-G),$$

T_1 (reckoned in Julian days) being the epoch immediately preceding the time t, when the north pole of the Earth's figure passed the Greenwich meridian, and θ being equal $\frac{360^{\circ}}{P}$. The theory also asserts that the constants of the formula, both the amplitudes and the epochs, or, rather, the periods between successive epochs, are variable. It is the law of this variability which Mr. Chandler now sets himself to determine. The method of the investigation hitherto has been to take definite series of observations of declinations of stars, and from these to deduce values of the constants corresponding to the epochs of those series respectively, as described in the preceding note; these results are now collected and tabulated in order of date to determine the law of their variability.

The results used in the present paper are those of the European series, nineteen in number, which have been published from time to time in the 'Astronomical Journal.' The values of the four quantities found by each series having been charted (the different values of T_1 being reduced to epoch 1865 by using a mean period of 428·6 days), they appeared to suggest a periodic law common to all four quantities, and were therefore treated as functions of an auxiliary angle ψ. A rigorous solution gives the following formulæ, representing (more or less accurately) the variation of these quantities:—

$$\begin{aligned} T_1 &= 2402327^{d} + 428^{d}{\cdot}6 \,.\, E + 55^{d} \sin\psi, \\ G &= 317^{\circ} - 44^{\circ} \cos\psi, \\ r_1 &= 0''{\cdot}135 + 0''{\cdot}05 \sin\psi, \\ r_2 &= 0\ {\cdot}135 - 0\ {\cdot}02 \cos\psi, \end{aligned}$$

where $\psi = (t - 2402327)\, 0^{\circ}{\cdot}015$ and E is the number of completed revolutions between the year 1865·25 and t.

According to the law for T_1, the value of the period of the 428-day term varies between $423^{d}{\cdot}3$ and $433^{d}{\cdot}9$ in a period of 65·9 years, and from the variation of G we find that the annual period varies between $361^{d}{\cdot}0$ and $369^{d}{\cdot}5$ in the same time.

A SUGGESTION IN THE THEORY OF MERCURY. By PROF. A. HALL ('Astronomical Journal,' No. 319).—It was found by Leverrier, and has since been confirmed by Newcomb, that the line of apsides of the orbit of Mercury is in motion at the rate of 38″ a century (Newcomb gives 43″) more than the known forces will explain. Various explanations have been offered, but none are satisfactory. Prof. Hall shows that the phenomenon can be explained by supposing the law of attraction to differ slightly from the inverse square. Assuming the law of attraction to vary as r^n (and using a formula of Bertrand's, $\frac{\pi}{\sqrt{r+3}}$, for the angle between the apsidal distances), he shows that $n = -2{\cdot}00000016$ will give the apses a motion of 43″ a century. Prof. Hall discusses the other effects on the motion of Mercury of this change in the law of attraction, and finds that the inclination and motion of the node will be unaffected. He also finds the equation between the time and the longitude, and compares it with the equation obtained by the law of the inverse square.

May we suggest the following method of treating the question of the effect of a law of force differing slightly from that of the inverse square which verifies Prof. Hall's result.

Taking the law of force to be $\frac{m}{r^{2+\Delta}}$, where Δ is small, we notice that

$$\frac{m}{r^{2+\Delta}} = \frac{m}{r^2} + \frac{m}{r^{2+\Delta}} - \frac{m}{r^2} = \frac{m}{r^2} - \frac{m}{r^2}\Delta \log r,$$

or a force $\frac{m}{r^{2+\Delta}}$ is equivalent to a force $\frac{m}{r^2}$ with a small disturbing force $-\frac{m}{r^2}\Delta \log r$. The equations of the planetary theory will give

$$\frac{d\varpi}{dt} = \frac{\Delta}{2}\frac{d\theta}{dt},$$

and as θ changes 14732″ per day and ϖ changes 43″ per century, we find $\Delta = {\cdot}00000016$, which agrees with Prof. Hall's result.

On this supposition a similar motion of the apse will result in the case of the Moon and of the planets. The Moon's apse will move 138″·5 in a century, those of Venus and of the Earth 16″·8 and 10″·4 per century respectively. If Prof. Hall's theory be correct these should also be shown by the observations.

F. W. D.

A PAPER on the sun-spots of 1893 by Hyacinthe Bruguière, in the 'Bulletin de la Société scientifique Flammarion de Marseille,' contains some interesting features, and more particularly a table of sun-spots visible to the naked eye in the year:—

Jan. 20–22	1	spot visible	during	3	days.
Jan. 27–30	1	,,	,,	4	,,
Feb. 12	1	,,	,,	1	,,
Mar. 14–16........	1	,,	,,	3	,,
July 8	1	,,	,,	1	,,
Aug. 8–12	2	,,	,,	4	,,
Sept. 1–4..........	1	,,	,,	4	,,
Oct. 23–25	1	,,	,,	3	,,
Dec. 19–22	1	,,	,,	4	,,
Total	10	,,	,,	27	,,

At the first glance one is apt to remark that the table seems large and impossible to any but skilled observers; but being led by curiosity to examine the Greenwich measures of sun-spots on the days noted in the table, the smallness of the spots seen occasioned a complete overhaul of the whole year's measures, and the table began to put on quite a different appearance; the wonder is not at the large number of spots visible to the naked eye, as observed by M. Bruguière, but that he should not have seen many others which were larger.

Tabulating the observed spots according to their distance from the centre, and giving their magnitudes in millionths of the Sun's visible surface, we get

Distance from Sun's centre, radius as unity.	Area in millionths of Sun's visible surface.	Distance from Sun's centre, radius as unity	Area in millionths of Sun's visible surface.
·06	431	·43	783
·10	380	·43	383
·11	515	·52	442
·13	394	·53	786
·16	529	·58	344
·25	400	·63	1179
·29	576	·64	703
·32	532	·68	774
·32	401	·68	427
·34	568	·75	1303
·35	466	·80	681
·36	534	·88	881
·39	330		

This table gives a rough idea of what M. Bruguière could see. The whole year's measures were examined and the spots which ought to have been visible to him, judging by this standard, noted. In all there were over 100 days on which such a spot occurred, and in many cases more than one spot at a time. Of course there were many of large area which on account of the foreshortening near the limb were not included.

Clearly something is wrong. What is it? We thought we had found a clue from the spot mentioned on Feb. 12. The largest spots on this day were two of about 210 millionths each; neither, of course, could be visible. The Greenwich photograph on this day was placed some 70 feet away and examined, with the result that a spot, which really was a combination of the two, became just visible. But if we follow this up it simply increases the number of days, and we are further away from an explanation than before. Can the nature of the spot be the cause?

The following table is given in the paper showing the number of spots seen by M. Bruguière with the naked eye in previous years:—

1887	4 spots.	1891	1 spot.
1888	2 „	1892	8 spots.
1889	1 spot.	1893	10 „
1890	3 spots.		

ANOTHER MONSTER TELESCOPE.—The competition to possess the largest telescope in the world is evidently not at an end yet. We learn from a note in the 'Westminster Gazette' that an observatory which is to be established in Pittsburg, U.S., is to have an instrument which will make even Yerkes look small. The object-glass of this is to be of fifty inches diameter, and the telescope and observatory are to be, like many other things in America, "the finest in the world." Messrs. Andrew Carnegie and H. Phipps, Jun., have offered to provide the greater part of the thirty thousand pounds necessary for this establishment, and Mr. Brashear is to make the objective, which, the 'Westminster Gazette' says, will *take at least a year.*

CORRECTION.—In vol. xvi. No. 198 (February 1893) we published an interesting article by Dr. Norbert Herz on the formation of Comets' tails. Dr. Herz in sending us his new work, an abstract of which is given in this Number, has taken the opportunity to favour us with some corrections to his previous communication. On page 100, line 30, the sentence should *read* "This proposition leads to the conclusion of a universe filled with vapour of those elements of which celestial bodies are formed. It is just to conclude that cometary bodies..." Again, on page 102, line 24, *for* "will not depend upon" *read* "has no influence on." And in the third table on page 99 in the last column the figures should *read* 4, 3 5, 5 4, 4 19, 19 20, 16.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 218. SEPTEMBER. 1894.

What shall we do with our Photographs?

[Concluded from p. 262.]

Last month I endeavoured to give some reasons for the opinion that at least two forms of micrometer are necessary for measuring astronomical photographs—one in which labour is a secondary consideration compared with accuracy, and another in which accuracy must be to a certain extent sacrificed for the sake of rapidity. There is, after all, nothing new in this distinction. In meridian work a wide distinction is maintained between the requisites of fundamental stars and others—for instance, in the number of observations considered necessary; in catalogues of stars three observations are made of ordinary stars, but many more of fundamental stars.

The only reason for remarking on this distinction is that it seems to have been momentarily forgotten in considering the Astrographic Chart. The idea of getting places of some million or two stars with extreme accuracy is so attractive that it is difficult to be content with less. But in practice we might just as well try to make as many observations of every star in a catalogue as are made of Polaris or other fundamental star. There is not time or labour available. Hence something must be sacrificed, and the only question is how to make this sacrifice as small as possible. I hope that a micrometer with a scale (or rather two scales at right angles) in the eyepiece, whereby the position of a star may be rapidly referred to the sides of the réseau square in which it falls, may be found one of the most advantageous solutions of the problem.

We pass on now to the other kind of measurement of a photograph—that of the density of the deposit at any point. It was remarked last month that to explore a photograph fully two elements must be measured—the position of any point and the density of the photographic deposit at that point. For determinations of position we use a micrometer; for determinations of density we must use some kind of photometer. This word is in use for this kind of instrument, and it is perhaps scarcely advisable to change it; but there is just a chance of its being misleading. The instrument with which I shall deal in what follows—Captain Abney's revolving sectors—measures the amount of light obstructed by the photographic deposit at any point of a negative, and is thus a photometer—a light measurer; but it must be noted that the light measured is *not* that which produced the deposit, nor is any information given about this light beyond that it has produced a given deposit in the time for which the photograph was exposed. The light measured is that from a totally different source, in the path of which the photograph is placed, and which is partially obstructed by the deposit. We can, moreover, conceive methods of measuring the density not depending on the measurement of light at all, though up to the present none of practical value has been suggested. If, however, there is any danger that the use of the word photometer for the instrument which measures the density at any point should seem to imply that the results give direct information as to the light photographed, some new name had better be adopted for that instrument.

Through the kindness of Capt. Abney I lately had an opportunity of using the revolving sectors at his laboratory in the South Kensington Museum; and a very short experience was enough to convince me that if measures of density on a photograph had not hitherto been numerous, it was not for want of a thoroughly efficient instrument. The observations are made with an ease, simplicity, and accuracy quite surprising to one who, like myself, uses the machine for the first time; and probably those who have had experience of other photometers would be the most surprised at the excellence of this. I cannot but think that it only needs to be generally known to be generally adopted, and used, in conjunction with the micrometer, to get a complete exploration of photographs in every observatory where photographs are taken.

The instrument has been described by Capt. Abney on several occasions, but a few words of description may not be out of place here. A beam of light is divided by a plane glass plate into two, one reflected (A) and one transmitted (B). Any inequality in the source of the beam thus affects A and B in the same ratio. This is important; for these beams A and B illuminate two minute screens placed in juxtaposition, and the measures are made by equalizing the illuminations of the screens; such measures are therefore independent of variations in the source, which leave the ratio of the intensities in A and B unaltered, and hence leave equal illuminations still equal.

In beam A is placed the photograph to be measured, which thus obstructs a portion of the light. To make the observations precisely at a given point of the plate, lenses are also interposed in the beam to throw an enlarged image of the plate on the plane of the two small screens, and one of these screens (*a*) is illuminated by beam A reduced by the photographic deposit on that very small region of the photograph whose image falls on *a*. The other beam (B) illuminates the other screen (*b*), and precautions are taken to shield screen *a* from the beam B, and screen *b* from the beam A. In beam B is placed the measuring apparatus, a rapidly whirling disk from which a pair of sectors, the size of which can be varied at will, are absent. The light of the beam B is thus alternately and very rapidly obstructed from and received by the screen *b*; and the portion of the time during which screen *b* is illuminated bears to the whole time the ratio which the arc of the sectorial aperture bears to the whole circumference. Now Capt. Abney has proved by experiment that the effect on the eye is just the same under these conditions as though the *intensity* of the beam were reduced in this ratio. What is really reduced is of course the total *exposure* of the eye to the beam, leaving the intensity unaltered; but when this is done by sufficiently rapid alternations, the result is indistinguishable from a reduction of the intensity.

If, then, we equalize the illumination of the two screens by opening or closing the sectorial aperture, and then read off the number of degrees in this opening, we have a measure of the amount of obstruction in beam A due to the point of the plate selected for examination. The measure is only a relative one, depending as it does on the ratio of beam A to beam B; but if on the plate there are impressions of some "standard squares," we can compare the density at any point of the plate with that in one of these squares, and so obtain information as to the ratio of the light which gave the image, to that which was used to make the standard squares. If there are no standard squares, we can still use the relative measures to make contour lines of intensity for the photograph under examination.

The device by which the opening of the sector is varied without stopping the rapid whirling is very ingenious. The disk is made up of two pairs of opposite quadrants, which can turn one over the other; and the disk is complete when one pair just fills up the gaps in the other pair, so that all light is cut off. If one pair be now turned through an angle θ° with respect to the other, two sectors of θ° will open in the disk, and the proportion $2\theta^\circ/360^\circ$, or $\theta/180$, of the light will be allowed to pass, which becomes one half when $\theta = 90$. To rotate one pair of sectors over the other they are connected by a screw of large pitch, so that the longitudinal motion of a button along the axis of rotation opens or closes the aperture as required. The button is of course whirling round with the sectors, but it can be slid up and down the axis by a steel fork without introducing so much friction as to stop the whirling sensibly.

When once the apparatus is set up, which does not take long, the operations are merely these: move the plate until the image of the required point falls on screen *a*; move the steel fork until the illuminations of the two screens are equal; read off. It will be seen that observations can be made simply and very quickly, until the eye gets tired.

The photographs on which I made observations were those of the corona of 1893. Points were examined along four radii extending approximately N., S., E., W. from the Moon's limb, and it may be interesting to give here one or two results of the measures:—

(1) The curve of diminution of density on the plate along a radius is smoother than might be expected. The streamers fade away very gradually. Time did not admit of measures along lines *crossing* the streamers.

(2) When the simple reading of the sector is tabulated against distance from the Sun's limb, the resulting curve closely resembles a probable error-curve, the vertex being at the Moon's limb and the asymptote corresponding to the skylight at a distance from the Sun.

(3) The curve does not approach the asymptote for several diameters from the limb. The photographs available give no information as to the nature of the light which has affected the plate, whether true corona or diffused light; but up to the edges of the plate (more than two diameters) the density of the photograph was still regularly diminishing, so that there is no photographic evidence *against* a coronal "extension." The most careful draughtsman would probably not have detected this fact, which the photometer reveals quite plainly and unmistakably.

(4) The curve for the N. and S. radii is almost precisely the same as that for E. and W. It should be remembered that 1893 is a year of maximum sun-spot activity.

These results are all merely relative, and give no information as to the absolute brightness of the corona, which as yet has not been quite worked out, though the standard squares have been measured. But they indicate directions in which photographs of old eclipses on which no standard squares have been impressed may be examined, and I hope to proceed with this work at an early date.

Further, a little experince of this kind with the photometer suggests its use in many other cases. It certainly seems to be the instrument with which to explore photographs of nebulæ, and in this way some information may be obtained as to changes in these wonderful bodies. Comets, too, may perhaps be thus examined: perhaps the comet which Mr. Schaeberle finds on the Eclipse photographs (1893), but which those who have examined the English negatives with the unaided eye cannot see, may be detected by this method. So strong is my faith in the photometer that I have wondered whether some of the plates taken for photographing the corona without an eclipse might not with advantage be re-examined with this instrument, which is so much more effective than the unaided eye.

I must not omit to mention another use to which Capt. Abney has proposed to put the photometer, viz. that of determining photographic star-magnitudes. He contends that the measurement of the mere *diameter* of a star-disk is unscientific, for no note is taken of the density of deposit within the boundary. Two disks of nearly the same diameter may differ greatly in blackness. What we should measure is the total amount of deposit in the image, and for this he uses the photometer in rather a different way—in what may be called an integrating method. A beam of parallel rays is condensed to a focus by a lens, the focus thus becoming a source of light. If part of the rays be cut off by inserting a star-image in the parallel rays, the amount of light concentrated in the focus, *i. e.* the intensity of the source, will be diminished, and the diminution measures the total obstructing effect of the image. The method will perhaps prove too cumbrous for general application; but it may probably be used with advantage to determine the relation between the total deposit and the diameter of the image in different parts of the plate.

In fact, it seems to me there is abundance of work for any number of these instruments, with the certainty of reward in results of great interest. It has often enough been remarked that a new department of activity has been opened to astronomers by the invention of the dryplate; but this is scarcely a strong enough view of the case. New work is not only possible but is urgent. There are plenty of people taking photographs—nay, there are plenty of photographs already taken—to keep employed a whole army of workers for years to come. Many who cannot afford an observatory, or even a large telescope, may be able to afford a micrometer or photometer, or both, and may measure some of the photographs which others have taken. The amateur of moderate means may do work of the greatest value without the necessity for great expense and without the discomforts of open-air observing, to which Dr. Roberts refers so feelingly in his beautiful book of photographs. Surely it is time to think seriously of these things! H. H. TURNER.

Popularising Science.*

"POPULAR science," it is to be feared, is a phrase that conveys a certain flavour of contempt to many a scientific worker. It may be that this contempt is not altogether undeserved, and that a considerable proportion of the science of our magazines, school text-books, and books for the general reader, is the mere obvious tinctured by inaccurate compilation. But this in itself scarcely justifies a sweeping condemnation, though the editorial incapacity thus evinced must be a source of grave regret to all specialists with literary leanings and with the welfare of science at heart. The fact remains that in an age when the endowment of research is rapidly passing out of the hands of private or quasi-private organisations into those of the State, the maintenance of an intelligent exterior interest in current investigation becomes of almost vital importance to continual progress. Let that adjective "intelligent" be insisted upon. Time was when inquiry could go on unaffected even by the scornful misrepresentations of such a powerful enemy as Swift, because it was mainly the occupation of men of considerable means. But now that our growing edifice of knowledge spreads more and more over a substructure of grants and votes, and the appliances needed for instruction and further research increase steadily in cost, even the affectation of a contempt for popular opinion becomes unwise. There is not only the danger of supplies being cut off, but of their being misapplied by a public whose scientific education is neglected, of their being deflected from investigations of certain, to those of doubtful value. For instance, the public endowment of the Zetetic Society, the discovery of Dr. Platt's polar and central suns, or the rotation of Dr. Owen's Bacon-cryptogram wheel, at the expense of saner inquiries might conceivably and very appropriately result from the specialisation of science to the supercilious pitch.

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* From 'Nature,' 1894, July 26.

It should also go far to reconcile even the youngest and most promising of specialists to the serious consideration of popular science, to reflect that the acknowledged leaders of the great generation that is now passing away, Darwin notably, addressed themselves in many cases to the general reader, rather than to their colleagues. But instead of the current of popular and yet philosophical books increasing, its volume appears if anything to dwindle, and many works ostensibly addressed to the public by distinguished investigators, succeed in no notable degree, or fail to meet with appreciation altogether. There is still a considerable demand for popular works, but it is met in many cases by a new class of publication from which philosophical quality is largely eliminated. At the risk of appearing impertinent, I may perhaps, as a mere general reader, say a little concerning the defects of very much of what is proffered to the public as scientific literature. As a reviewer for one or two publications, I have necessarily given some special attention to the matter.

As a general principle, one may say that a book should be written in the language of its readers, but a very considerable number of scientific writers fail to realise this. A few write boldly in the dialect of their science, and there is certainly a considerable pleasure in a skilful and compact handling of technicalities; but such writers do not appreciate the fact that this is an acquired taste, and that the public has not acquired it. Worse sometimes results from the persistent avoidance of technicality. Except in the cases of the meteorologist, archæologist, and astronomer, who are relatively free from a special terminology, a scientific man finds himself at a great disadvantage in writing literary English when compared with a man who is not a specialist. To express his thought precisely he gravitates towards the all too convenient technicality, and forbidden that, too often rests contented with vague, ambiguous, or misleading phrases. It does not follow that, because, what from a literary standpoint must be called "slang," is not to be used, that the writer is justified in "writing down" as if to his intellectual inferiors. The evil often goes further than a lack of precision. Out of a quite unwarrantable feeling of pity and condescension for the weak minds that have to wrestle with the elements of his thought, the scientific writer will go out of his way to jest jests of a carefully selected and most obvious description, forgetting that whatever status his special knowledge may give him in his subject, the subtlety of his humour is probably not greatly superior, and may even be inferior to that of the average man, and that what he assumes as inferiority in his hearers or readers is simply the absence of what is, after all, his own intellectual parochialism. The villager thought the tourist a fool because he did not know "Owd Smith." Occasionally scientific people are guilty of much the same fallacy.

In this matter of writing or lecturing "down," one may even go so far as to object altogether to the facetious adornment of popular scientific statements. Writing as one of the reading public, I may testify that to the common man who opens a book or attends a lecture, this clowning is either very irritating or very depressing. We respect science and scientific men hugely, and we had far rather they took themselves seriously. The taste for formal jesting is sufficiently provided for in periodicals of a special class. Yet on three occasions recently very considerable distress has been occasioned the writer by such mistaken efforts after puerility of style. One was in a popular work on geology, where the beautiful problems of the past of our island and the evolution of life were defaced by the disorderly offspring of a quite megatherial wit—if one may coin such an antithesis to "etherial." One jest I am afraid I shall never forget. It was a Laocoon struggle with the thought that the huge subsidiary brains in the lumbar region of *Stegosaurus* suggested the animation of Dr. Busby's arm by the suspicion of a similarly situated brain in the common boy. The second disappointment was a popular lecture professing to deal with the Lick Observatory, and I was naturally anxious to learn a little of the unique appliances and special discoveries of this place. But we scarcely got to the Observatory at all. We were shown—I presume as being more adapted to our intelligence—numerous lantern-slides of the road to the Lick Observatory, most of them with the "great white dome" in the distance, other views (for comparison probably) with the "great white dome" hidden, portraits of the "gentlemen of the party on horseback," walks round the Observatory, the head of an interesting old man who lived in a cottage near, the dome by moonlight, the dome in winter, and at last the telescope was "too technical" for explanation, and we were told in a superior tone of foolish things our fellow common people had said about it. For my own part, I really saw nothing very foolish in a lady expecting to see houses on the moon. My third experience was ostensibly a lecture on astronomy, but it was really an entertainment—and a very fair one—after the lines of Mr. Grossmith's. "Corney Grain in Infinite Space" might have served as a title. It was very amusing, it was full of humour, but as for science, the facts were mere magazine *clichés* that we have grown sick of long ago. And as a pretty example of its scientific value I find a newspaper reporter, whose account is chiefly "(laughter)" with jokes in between, carried away the impression that Herschel discovered Saturn in the reign of George the Third.

Now this kind of thing is not popularising science at all. It is merely making fun of it. It dishonours the goddess we serve. It is a far more difficult thing than is usually imagined, but it is an imperative one, that scientific exponents who wish to be taken seriously should not only be precise and explicit, but also absolutely serious in their style. If it were not a point of discretion it would still be a point of honour.

In another direction those to whom the exposition of science falls might reasonably consider their going more carefully, and that is in the way of construction. The fundamental principals of construction that underlie such stories as Poe's "Murders in the Rue Morgue," or Conan Doyle's "Sherlock Holmes" series, are precisely those which should guide a scientific writer. These stories show that the public delights in the ingenious unravelling of evidence, and Conan Doyle need never stoop to jesting. First the problem, then the gradual piecing together of the solution. They cannot get enough of such matter.

Enough has been said to show along what lines the genuine populariser of science goes. There are models still in plenty; but if there are models there are awful examples—if anything they seem to be increasing—who appear bent upon killing the interest that the generation of writers who are now passing the zenith of their fame created, wounding it with clumsy jests, paining it with patronage, and suffocating it under their voluminous and amorphous emissions. There is, I believe, no critical literature dealing generally with the literary merits of popular scientific books, and there are no canons for such criticism. It is, I am convinced, a matter that is worthy of more attention from scientific men, if only on the grounds mentioned in my opening paragraphs.

H. G. WELLS.

The Bright Projections on Mars.

A TELEGRAM from M. Perrotin, of Nice, on Aug. 6, announcing the observation of a bright prominence beyond the terminator of Mars, and a subsequent announcement by Mr. Stanley Williams of a similar observation, have renewed scientific interest in this class of phenomena, and have also created some sensational interest in the public press*. It may not be out of place to give categorically the recorded observations of this kind.

The first hint of such bright markings came from Prof. Schiaparelli, who, in 1888, in publishing some observations of white spots stated that the whiteness was always more pronounced when the spots were near the edge of the disk, but he did not observe the brightness *beyond* the terminator. In the same year M. Terby observed similar white spots, which were invisible until they approached the western edge of the disk, when they appeared very bright, and were apparently seen beyond the edge of the disk by irradiation; but it was not until 1890 that the phenomena of obvious projections were seen. On July 5 of that year from $10^{h}\ 0^{m}$ to $10^{h}\ 30^{m}$ Pacific Standard Time the observers at Lick saw a narrow elliptical white spot from $1''\cdot 5$ to $2''\cdot 0$ long projecting from and making a small angle with the line of the terminator. At $10^{h}\ 30^{m}$ the spot was certainly within the illuminated disk, still visible as a white patch on a dark background. On the next night July 6, from $8^{h}\ 3^{m}$ to $10^{h}\ 25^{m}$ Pacific Standard Time, two projections of the same kind were seen, one of which was no doubt the object observed on the preceding evening. The latitude of this principal projection was about +40°, and the apparent Martian longitude of the terminator during the times of observation ranged from 45° to 52° on the first night, and from 6° to 41° on the second. It is to be remarked that the additional spot seen on July 6 was situated at the end of a long bright stripe on the surface of the planet.

During the opposition of 1892 these phenomena were again seen. M. Perrotin, at Nice, saw bright projections beyond the terminator on June 10, from $15^{h}\ 12^{m}$ to $16^{h}\ 17^{m}$ Nice Mean Time in latitude about −30°, the longitude of the terminator during this hour ranging from 212° to 228°, on July 2 from $14^{h}\ 10^{m}$ to $14^{h}\ 40^{m}$, and on July 3 from $14^{h}\ 11^{m}$ to $15^{h}\ 6^{m}$, in latitude −50° on each evening, from which it may reasonably be inferred that these objects, whatever they were, were in the same region of the planet (about longitude 335°). M. Perrotin says that these were seen with great distinctness, and that it is scarcely possible to consider them the results of illusion.

At this opposition the observers at Lick were Professors Hussey and Campbell; the former observed from July 2 to 17, and states that on no night when he looked did he fail to see a prominence. Prof. Campbell observed them on five nights between July 10 and

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* 'Punch' suggests that Mars is about to take the place of the sea-serpent and the large gooseberry in the annual dull newspaper season.

17, but after this date no one at Mount Hamilton saw these projections, although they were looked for up to August 17. All the prominences observed at Lick were between latitudes —30° to — 50°, except one or two at about latitude —25°. The most prominent were observed on July 11 and 13, the same object being doubtless observed on the two evenings (latitude —47°, longitude 357°) in a region known as *Noachis*.

From Arequipa, where Mr. W. H. Pickering was observing Mars in 1892, there are no detailed reports of similar observations. In 'Astronomy and Astro-Physics' for December 1892 he says: "Clouds have on several occasions been observed to project beyond the terminator and also beyond the limb. The height of some of these clouds has been measured, and it appears that some of them attained an altitude of at least twenty miles."

Since 1892 no observations of this kind have been made until August 6 of this year, when, as mentioned above, M. Perrotin announced an observation of a brilliant projection beyond the terminator, and again on August 19 Mr. Stanley Williams observed a similar phenomenon; the American observations of the planet will be waited for with interest. As to the cause of these, there appear to be two rival explanations. One, as suggested in Mr. W. H. Pickering's report of his observations, that these luminosities are bright clouds; and in favour of this theory he says that the small mass of the planet is not inconsistent with clouds at such great altitudes as these observations would require. On the other hand, the observations show in many cases that these bright objects are permanent on the planet, a quality which we find difficult to attach to clouds.

The other theory advanced by Prof. Campbell in an article in Number 35 of the 'Publications of the Astronomical Society of the Pacific,' and to which we are indebted for much of this, is that these projections are due to mountain-chains lying across the terminator of the planet, in some cases covered with snow, in others not necessarily so. A chain of mountains parallel to the planet's equator, by reason of their length, would give the permanence of the phenomenon which has been observed, as on July 11 and 13, 1892, when the luminosity was observed for two hours or more, during which time 800 or 900 miles of the planet passed over the terminator. Also it will be seen, on considering the geometry of the question, that the observed distance from the terminator is not a direct measure of the altitude of the mountain, if the object is such, but it is a quantity into which the length of the chain enters with much effect.

Prof. Campbell suggests that the Martian latitude and longitude of every such observed prominence should be computed with accuracy, and when this determined position is on the central meridian, the planet may be scrutinized to find whether it falls on a dark or bright marking, which will supply some evidence as to the character of the region.

A short Sketch of the State of Astronomy in the United States.*

THE bold explorations of Americans in the regions of electricity, the happy ingenuity that they bring to bear in perfecting the appliances of industrial mechanism, do not prevent them from indulging their traditional taste for astronomy. Of all sciences it is perhaps the most abstruse and at the same time the most popular; its theory requires the deepest calculation, and its phenomena strike most vividly the imagination of young people, clothed as they are by the mystery of celestial infinity.

There exists at the present time in the United States nearly one hundred observatories, public and private. The most important are those of Harvard University, Mount Hamilton (Lick), and Washington (Naval), which are in the first rank of the observatories of the world. Then follow the observatories of Cincinnati, Glasgow, Madison, Newhaven, New York (Columbia College), Northfield, Princeton, Rochester, University of Virginia, Georgetown, and others. Though the first observatory constructed in the United States is now scarcely sixty years old, many already have made a name in the annals of astronomy.

The observatory at Washington is distinguished for its origin. Its first director, M. Matthieu Maury (descendent of a French family which had emigrated at the revocation of the Edict of Nantes), formerly a marine officer, conceived the idea, scarcely half a century ago, of preparing charts of the winds and currents. He carefully reduced observations taken from log-books of the vessels making the voyage from New York to Rio Janeiro, and succeeded in tracing a new sea-route much more advantageous than that hitherto used. The American vessel—the 'Wright'—which ventured this route for the first time accomplished the journey, going and returning, in the same time that was formerly occupied in going only to Brazil by the former course. Encouraged by this success, he extended his researches, and most of the long voyages were shortened by about a half. Pure science was no less cultivated at Washington Observatory, whose first astronomers—Coffin, Hubbard, and Walker—practised the most precise methods of European savants. During the last twenty years Professors Newcomb, Harkness, and Hall have made themselves known by admirable work. It is not for us here to review their theoretic studies, it will suffice to recall that the last-named discovered the satellites of Mars, and thence determined anew the mass of that planet. This discovery, made by the aid of a 26-inch objective (made by Alvan Clark of Cambridge, near Boston), showed unmistakably the utility of large instruments. Then began a struggle of the object-glasses, of the same kind, but for a more pacific purpose, as the rivalry for possession of the largest guns. In 1880 M. Bischoffsheim offered to the Observatory of Nice a telescope, the object-glass of which should be 30 inches diameter. Eight years later the Lick Observatory received a refractor of 36 inches, and recently, at the Exhibition of Chicago, there was exhibited a telescope destined to carry a glass 40 inches across to be used at the Yerkes Observatory.

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* M. Jules Violle, a well-known French physicist, has recently been visiting some of the observatories of the United States. Extracts from the report of his excursion were published in 'Ciel et Terre' for July 16, to which publication we are indebted for the following.

It is true that science in the United States possesses a certain undoubted advantage: she is rich in money and enjoys resources almost inexhaustible, strengthened by individual munificence. The Lick Observatory, thus called from the name of the founder, owes its existence to one of these private gifts, a gift truly princely, the making of which the democratic American has for some years acquired the happy knack. This Mœcenas of Astronomy left by will the sum of $700,000 for the construction of an observatory, with the condition of placing in it the largest telescope in the world. His original idea was to place the "largest telescope in the world" in the heart of San Francisco. It required much diplomacy on the part of American astronomers to persuade him that isolation—the vast horizon and pure air of Mount Hamilton (the observatory is about 4000 feet above sea-level)—conduced better to astronomical observation than the agitation of a populous city, where the atmosphere is always thick with dust and smoke. Mount Hamilton combines the advantages which in France led to the placing of the observatory founded by M. Bischoffsheim on Mont Gros. Just as Mont Gros, situated upon the "azure hill," dominates the Mediterranean, so Mount Hamilton looks down upon the Pacific over the lemon-groves and the orchards of San José. The exterior of the Lick Observatory is of solid appearance, but does not present the imposing grandeur which distinguishes the Observatory of Nice. As to the internal appointments, they are perfect in all particulars. Among many ingenious arrangements introduced also in the Washington Observatory, which has recently been transferred to an eminence at the north-west of the capital, we may note the floor working vertically under the great telescope, which permits the observer to follow its motion with ease. These and other convenient arrangements ensure at the same time precision of measures and ease of observing.

So much generosity and intelligent effort have not proved unfruitful. By the aid of the famous telescope—which was really the largest in the world ten years ago, at the time of its installation—Prof. Barnard has succeeded in discovering the fifth satellite of Jupiter. The curious spectra that Prof. Campbell has shown and the remarkable photographs of the Sun taken by Prof. Schaeberle (the Californian rival of M. Janssen) bear witness to active researches followed with success in all branches of astronomy. Nor must we neglect to mention the observations and investigations of double stars made by Mr. Burnham, who will continue his work with the Yerkes telescope at Chicago. In fact, the Lick Observatory is a scientific centre of the first order, that Prof. Holden, the eminent director, cherishes with a jealous zeal.

Although the Lick Observatory attached to the University of California receives pupil astronomers, and is open to the public for several hours each day in accordance with the will of the founder, observatories abound in the region. Berkeley, seat of the University of that name, holds classes for students of science under the direction of Prof. Soulé. At San Francisco the learned Professor Davidson, director of the hydrographic and geodetic service for all the region of the Pacific, has installed the well-known observatory which bears his name. On the other side of the bay opposite San Francisco, at Oakland, upon the road to Berkeley, are found many scientific establishments of the same kind—the Chabot Observatory, devoted to the instruction of all and especially to young scholars; the observatory of Mr. Burckhalter, who contrived with his own hands the masonry, the carpentry, and even the movement of the equatorial in the leisure moments of an active life, devoted to business; there is another private observatory the partial construction of which is in the same way the work of its proprietor Mr. Blinn; and these, it must be remembered, are the institutions of only a single State.

In the other parts of the Union how many celebrated observatories of different titles deserve to be noted. Let us remark first Harvard, where Prof. Pickering, following the researches of Draper, has so happily developed the different branches of celestial physics, spectroscopy, photometry, and photography without forgetting meteorology, for the study of which the Harvard authorities have just installed a station at Peru at an altitude of nineteen thousand feet, the highest meteorological station in the world. Harvard Observatory, during the last fifty years, has published a series of forty volumes of its 'Annals' and has contributed much to the progress of astronomy. Its personal establishment forms a veritable army of astronomers and computers. It comprised forty persons in 1890, among whom were sixteen ladies. It may be added that in the United States more than in other countries one meets with ladies pursuing the career of astronomy. Next should be mentioned the Observatory of New York, where Dr. Rutherfurd made his admirable photographic pictures of the Moon; the Yerkes Observatory of Chicago, the young director of which, Mr. George Hale, already renowned for his work, will have at his disposal the powerful instrument which was seen at the Exhibition; the observatories at Albany, Allegheny, Ann-Arbor, Madison, Newhaven, Denver, and of twenty other towns scattered over the country. America appears truly as the land elect for astronomy; the flag covered with stars is perhaps a significant emblem.

American investigations have above all extended into the region of Astrophysics, where Pouillet has left a valuable mark by his measures of the solar heat. Mr. Langley, when he superintended the Observatory of Allegheny, proposed to measure the heat ray from any source of heat whatever, and for the purpose conceived the bolometer, an instrument of prodigious delicacy. Everyone knows that the resistance offered by a metallic wire to the electric current depends on the temperature of the metal, and that resistance can be measured by the arrangement known to electricians as a *bridge*. A very fine wire interposed in a bridge will constitute, therefore, the most sensitive of thermometers. On this principle the bolometer is constructed, an instrument of such sensitiveness as to record a variation of temperature of a millionth of a degree. The inventor has used this precious instrument to elucidate many questions of celestial physics. We owe to him a remarkable study of the solar spectrum down to the extreme infra-red region, where no light is visible to the eye, but vibrations exist, exhibited only by their heat.

Scarcely an hour's railway journey separates Washington from Baltimore, where we visit another scientific establishment of the first rank, the John Hopkins University, founded in 1876 by a city merchant, who gave for this work three and a half million dollars. The Physical Institute here is especially organized for the study of electricity and of spectra, as one would expect from the works of its director Mr. Rowland. It must be remarked that to obtain the best results from the principles of spectrum analysis, it is necessary to have the spectra defined as perfectly as possible, and the use of a prism scarcely permits this. The apparatus designed by Fraunhofer on the contrary, the grating, gives to different spectra an absolute comparability, the deviation of each wave being proportional to its wave-length. Gratings, formerly, were difficult of construction. Mr. Rowland has discovered a means of making them much larger and more perfect by the help of a special machine, which on a width of ten centimetres marks no less than fifteen thousand lines. This perfection has been of great importance to spectroscopy. The scientific movement of which we have given here some idea is not concentrated only in the old Eastern States, which form a trans-Atlantic Europe, but extends to the States of later formation.

Americans have understood that high intellectual culture is not only a question of elegant luxury or of national self-love, the prosperity and the future of the country even depend on this. A glance thrown on the different countries of the two hemispheres is sufficient evidence of this fact.

Observations of the Perseids.

On August 10 we tried to gather a good harvest of Perseids, but only had a clear sky from $12^h\ 22^m$ till $13^h\ 12^m$; and even this short term was not wholly without clouds. Seventy-three shooting-stars were marked on our map, a rather small one, out of the set of meteor maps just now published by Dr. C. Rohrback, at Gotha.

Eighteen of them seemed to belong to Perseus; they all left a pretty bright trail, and had a common general aspect as far as concerns their brilliancy, velocity, and duration, and the length of their paths. Six meteoroids might, with equal accuracy, be referred to two radiants: I. ($\alpha = 38^\circ$, $\delta = +57^\circ$) and II. ($\alpha = 43^\circ$, $\delta = +54^\circ{\cdot}5$). Moreover, five belonged to I. only, 7 to II. only. Though these points were very near to each other, we could not omit one of them, but were obliged to keep them both. The point II. is very nearly the same as the point IV. we found in our observations of the Perseids of 1892 ('Observatory,' No. 193). Of the five meteors that probably did not belong to the Perseid-shower, three radiated pretty accurately from δ Cassopeiæ; these, too, left a bright trail. The two others seemed to be accidental ones.

The night of August 13 was very clear; unfortunately the Moon prevented us from well distinguishing the smaller fixed stars, and therefore is likely not to have improved the accuracy of our drawing. From $13^h\,30^m$ till $15^h\,0^m$ we saw 29 meteors, 14 of which seemed to be sporadic ones; seven might be referred to the point III. ($\alpha = 47^\circ$, $\delta = 58^\circ$) and eight to IV. ($\alpha = 43^\circ{\cdot}5$, $\delta = 54^\circ$). In these numbers are included five shooting-stars that might belong to either point. Here again the choice between the two radiants was difficult. Besides, five meteors seemed to radiate from the point V. ($\alpha = 22^\circ$, $\delta = 53^\circ$) in Cassiopeiæ; they all were without trail, while, on the other hand, those belonging to III. and IV., with only one exception, left a bright streak.

The points IV. and II. are nearly identical, and combined with I. and the above-mentioned IV., found in August 1892, have a common centre of gravity, which nearly coincides with that of Persei, the radiant indicated by Schiaparelli ('Osservazioni delle Meteore luminose nell' anno 1894').

At the middle time of observation, viz. about $13^h\,20^m$, the average zenith-distance of the five radiant-points being $28^\circ{\cdot}5$ and the distance from the apex about 40°, the zenith-attraction is readily found by means of Schiaparelli's tables ('Note e rifl. sulla Teoria astr. delle Stelle cadenti') to be $0^\circ\,16'$, and therefore may be neglected.

Dr. Lehman-Filhés's tables ('Die Bestimmung von Meteorbahnen,' Berlin, 1883) gave us the following parabolical elements of the orbits, corresponding to the observed radiant-points:—

	Long.	Lat.	☊.	*i*.	π.	*q*.
	°	°	°	°	°	
I.	56	+39	138	114	300	0·976
II.	58	36	138	118	294	0·957
III.	62·5	39	141	113	295·5	0·950
IV.	58	35	141	120·5	304	0·978
V.	43	40	141	112	338·5	0·977

The elements of the comet 1862 III. are:—

T = 1862 Aug. 22·949 Berlin M.T.

π ……	290° 12′	q ……	0·963
☊ ….	137 27	e ……	0·961
i ……	113 34		

Corresponding to these elements we found, by means of Dr. Lehman-Filhés's tables, for the true radiant-point:

Long. 59°·5, Lat. +38°·5,

i. e. very nearly the mean of the points I., II., III., and IV.

A. A. Nÿland.
J. C. Bolt.

Utrecht, 1894, Aug. 25.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The first Welsh Astronomer.

Gentlemen,—

A short time ago I was writing to you about the first Englishman who is known to have made astronomical observations, Thomas Digges, who observed the famous Cassiopeia star in 1572. An article by Mr. Mee, F.R.A.S., of Cardiff (author of the well-known 'Observational Astronomy'), in the new monthly magazine (of which he has kindly sent me a copy) 'Wales,' recalls my attention to the earliest astronomical observations made in Wales, by Sir William Lower in Caermarthenshire. In 1610 he first used telescopes, or cylinders as he called them; and he and his young friend Protheroe were amongst the earliest observers of solar spots. But I wish rather to speak of his observations of the comet of 1607, known after its next return in 1682 as Halley's, which were of course made with the unassisted sight. The results were sent to his "especiall good friend Thomas Harriotte att Sion neere London," and remained unpublished until they were unearthed, together with Harriot's own observations, by Baron von Zach in 1784, and published in the first supplement to the 'Berliner Jahrbuch' in 1793. It is to be regretted that, from a want of familiarity with English manuscripts, the Baron made several mistakes in transcribing them, which were not detected till Rigaud made a fresh examination of these, publishing the result at the end of his account of Bradley in 1832; and a supplement to this, containing some additions and corrections, appeared in the following year. Zach erroneously attributed Lower's observations of the comet of 1607 to Nathaniel Torporley, and this mistake is copied into the 'Repertorium der Cometenastronomie' of Carl, who apparently had not seen Rigaud's correction. He also supposed they were made at Ilfracombe (Illfordcombe, as it was then written) in Devonshire, the fact being that Lower first saw the comet on the night of Sept. 17, when in a boat on which he had just embarked to pass from that place to Kidwelly, on the eastern side of Caermarthen Bay; but the actual observations were made at Mount Martin, an eminence a short distance to the north of Kidwelly, close to Traventi or Treventy, which appears to have been the name of an estate of which he had become possessed through his wife, an heiress of the Perrot family. Lower himself was of Cornish stock, and some information respecting his family will be found in Mr. E. H. W. Dunkin's 'Monumental Brasses of Cornwall.' The positions of the comet, determined with "a crossstaffe, sent downe for measuring of land," are given from Sept. 22 to 29 on six nights (Sept. 25 was "cloudie," and on Sept. 28 the worthy astronomer notes that he "was gossipinge"), and on Sept. 30 they were sent to Harriot. Von Zach makes another mistake in supposing that Sion, then the abode of the latter, was Sion College, which was not built until 1623; the real place was Sion House near Isleworth, where he resided by the permission of his patron, the Earl of Northumberland. Lower's observations are erroneously attributed, in the 'Dictionary of National Biography,' to Harriot, who does not appear himself to have seen the comet until Sept. 21; his last observation of it was made on Oct. 13.

Mr. Mee gives in his article some interesting particulars respecting Sir William Lower's observations after he became possessed of telescopes a year or two later, and his enthusiasm in the use of "cylinders," as he called them. As already mentioned, he was assisted in these by his young friend John Protheroe ("we Traventane philosophers," as he playfully puts it), of Nantyrlrebog or Hawksbrook, between Kidwelly and Caermarthen. But I have troubled you long enough on this subject, and remain,

Yours faithfully,

Blackheath, 1894, Aug. 7. W. T. LYNN.

The Chaldean Planetary Observations.

GENTLEMEN,—

Whenever a transit of Mercury occurs another will usually take place at the end of a period of 46 years, on account of the near correspondence between 191 periods of the planet and 46 of the Earth. Accurately the former amounts to 16801·89 days and the latter to 16801·50 days.

Although there is no reason to suppose that the ancient Chaldeans could have observed transits of Mercury, it is interesting to find that they did notice the near commensurability of these periods, probably by comparing long series of dates of the greatest elongations of the planet from the Sun. These take place at mean intervals of 115·87 days, 145 of which make 16801·15 days, differing only 0·35 of a day from 46 years, at the end of which time Mercury will be again conspicuous in the morning or evening at the same time of the year.

I have been led to these remarks by a conversation with Mr. T. G. Pinches, of the British Museum, who informed me that in the Babylonian tablets the number 46 was found to be associated with the planet in question *. Eight years are in like manner connected by them with Venus; and whilst five synodic periods of Venus are equal to 2919·60 days, eight years amount to 2922 days, differing by only 2·4 from the above, so that if Venus were observed at greatest eastern or western elongation she would be so again eight years afterwards within three days of the same date.

This correspondence is not so exact as that of the 46 years in the case of Mercury, and taking into account the frequent difficulty of seeing the latter, it is a striking testimony to the perseveringness of the Chaldean observations that they should have noticed that period.

Yours faithfully,

Blackheath, 1894, Aug. 12. W. T. LYNN.

The Coronal Comet of April 16, 1893.

GENTLEMEN,—

The Lick Observatory has just secured copies of the eclipse photographs taken by Prof. W. H. Pickering in Chile on April 16, 1893. The coronal comet is unmistakably shown on at least three of the plates (Nos. 454, 467, and 468), having practically the same form and position as in the Lick Observatory photographs, the difference in the times of exposure at the two stations being only a fractional part of a minute.

The comet was discovered on the Lick Observatory plates, and subsequently copies of the negatives of the British expeditions to Brazil and Africa were received at the Lick Observatory, and the comet was found on these plates also, the cometary character of the object being firmly established by the motion (see Astr. Journ. No. 318).

I learn from the 'Observatory' for July 1894 (p. 254), received July 25, that the originals from which these copies were made have been examined in London, and that the comet has not been seen. It is true that the British negatives of the eclipse are not so rich in detail nor so strong in contrasts as our own, but there is no question that the comet is visible on them also. If the observers have not seen it after having their attention directed to it, it can only be because they have not properly examined the negatives. I will undertake to show this comet to anyone on at least ten Lick Observatory negatives, on at least three Harvard College copies, and on at least four of the British copies.

I have just made and sent to the Royal Astronomical Society a negative copy of one of the British positives, and indicated the exact position by a series of arrows. As the object is now shown in a fairly conspicuous manner it cannot fail to be seen at once.

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* Father Epping speaks of this first in the 'Astronomisches aus Babylon,' p. 189, and Mr. Pinches has found it referred to in another Babylonian tablet.

Yours faithfully,

Lick Observatory, 1894, July 26. J. M. SCHAEBERLE.

OBSERVATORIES.

THE following notes on the work of some foreign observatories during the year 1893 have been abridged from the 'Vierteljahrschrift der astronomischen Gesellschaft,' and are similar to those given in Nos. 208, 192, 180, &c.

BAMBERG. *Ernst Hartwig.*—The unfavourable weather has considerably limited the use of the large heliometer. A few observations of the Moon have been made for the determination of libration; the Sun's diameter has been measured several times; the Comet Quénisset (1893 II.) has been observed on three nights, Comet Denning on one night, and Comet Gale on four nights; and the places of six variable stars were determined on nine nights. With the 6-inch refractor variable stars have been observed on 80 nights. The Repsold transit-circle has been employed by Dr. Lorenzen for the determination of the constant of aberration and the variation of the latitude.

Dr. Braun has been making researches on atmospheric electricity, and the meteorological observations have been made as usual.

BASEL. *A. Riggenbach-Burckhardt.*—The instruments have been constantly used by the students of the University. In connection with the Geodetic Survey of Switzerland, the latitude of the Observatory has been determined and is 47° 33′ 35″·70.

BERLIN. *W. Foerster.*—With the transit-circle in the hands of Dr. Baltermann, 4032 transits and 3535 declinations have been observed. There have been 805 determinations of level error, 408 of azimuth error, and 17 of the collimation. Altogether 2100 stars have been observed. The reductions are completed. With the small instrument the positions of the stars have been determined which were used in finding the latitude of Honolulu. With the 9-inch refractor Prof. Knorre has made 384 determinations of position-angle and 464 determinations of distance of double stars. These observations are completely reduced.

BONN. *F. Küstner.*—The old transit-circle of Pistor and Martins, with which 130,000 observations have been made during the last 50 years, has been removed from the east to the west room, and been replaced by a Repsold meridian-circle of 6 ft. focal length.

The printing of the Zone Catalogue from 40°–50° decl., including 18,457 stars, is finished all but the introduction.

Holmes' Comet was observed on four nights, and the distance of Saturn from γ Virginis measured on April 7, 8, 9, 10.

Dr. Mönnichmeyer has obtained 215 observations of nebulæ on 33 evenings, and has completed his series of observations begun in 1891. He has also determined the latitude for 1893 of the Observatory to be 50′ 43′ 44″·52, with a mean error of ±0″·10.

BRESLAU. *J. G. Galle.*—Meteorological and magnetic observations were made here. The latter were somewhat disturbed by an electric tramway.

DRESDEN. *Dr. B. von Engelhardt.*—Observations of double stars having a proper motion of at least 0″·1 with a 12-inch Grubb refractor and Repsold micrometer. In addition, nebulæ have been observed on 72 nights, Comet Holmes on one night, and Quénisset on two nights. The observations are completely reduced.

DÜSSELDORF. *R. Luther.*—With the assistance of his son Dr. Luther has made 96 observations of minor planets. Altogether 1699 observations of 184 planets have been made here since 1847.

GENEVA. *R. Gautier.*—The electric lighting which was installed last year has been unsuccessful, and has been replaced by another system. An examination of the pivots of the transit-circle, which were reground in 1892, shows that they are truly circular, but that their diameters are not exactly equal. With the Plantamour equatorial observations of nebulæ, lunar craters, and planets were made. M. Kammermann observed Comet Holmes on 11 nights, Comet Quénisset on 16 nights, and Comet Brooks on 2 nights. Time-determinations were made regularly. 499 watches were tested in the year*. A new determination of the altitude of the Observatory above the sea-level has been made, agreeing with that of 1887.

[To be continued.]

SECHZEHNTER JAHRES-BERICHT ÜBER DE THATIGKEIT DER DEUTSCHEN SEEWARTE FÜR DAS JAHR 1893 (HAMBURG).—This report, although a non-astronomical one, is perhaps not without interest. From it we gather that a systematic overhaul of ships' logs is undertaken by the Institute. This means a huge piece of work, for no less than 65,436 observations (meteorological) were gleaned from the Imperial Navy alone. The observations from other sources bring up the number to 361,178 to be tabulated and digested. These observations are spread all over the world, and are used for determining the direction of winds, currents, &c., and the behaviour of cyclones. In addition to this the Institution has tested a large number of barometers, thermometers, compasses, sextants, ships' lanterns, and chronometers, and has made researches into the variation of the compasses in iron ships. The Institution appears, therefore, to be a combination of Kew and our Hydrographic Office.

* Similar to work done at Kew.

PUBLICATIONS.

Scheiner's Astronomical Spectroscopy *.—In February 1891 we had the pleasure of reviewing 'Die Spectralanalyse der Gestirne' by Dr. Scheiner, of the Potsdam Observatory, and at that time remarked that it "ought to serve—either in the original or translated—as a text-book to every worker in sidereal physics." We therefore heartily welcome the present translation by E. Brant Frost, M.A., of Dartmouth College, which entitles it to rank as *the* book on the subject.

So many advances have been made in the short interval since the appearance of the German edition that a mere translation was not to be thought of, consequently we have every information up to date and *incorporated in the body of the work*, so that it is straightforward reading and the footnotes are not the most prominent portion. The whole work is so carefully planned, and nowhere can we find theories woefully dressed up as facts, that criticism seems entirely out of place. For this reason, and for the sake of those who did not care to tackle the German edition, we give an outline of the contents, merely drawing attention to the more prominent features.

The treatise is divided into four parts, viz.:—

I. Spectroscopic Apparatus.
II. Spectroscopic Theories.
III. Results of Spectroscopic Observations.
IV. Spectroscopic Tables.

Part I.—The use and method of using every piece of apparatus connected with the spectroscope is fully described, and diagrams given where their introduction serves to elucidate the text. We note here that the Greenwich Half-prism Spectroscope is unblushingly condemned by Dr. Scheiner. The Lick and Potsdam spectroscopes are completely described, and a place is found for a valuable chapter on the Photographic Reproduction of the Spectra of Celestial Objects—a very straightforward and practical description, in which the attendant difficulties are clearly stated.

Part II.—We have here a historical sketch of the theory of Spectroscopic Analysis, and perhaps the fullest and clearest detailed account of Kirchhoff's Law and Doppler's Principle.

Part III.—This portion embodies the results of spectroscopic observations; and here the broad views both of Author and Translator are very conspicuous, and they are to be congratulated on the able way in which they have kept off the rocks. We are at once introduced to the Solar Spectrum, and we notice that the wave-lengths used as a standard throughout are on Rowland's scale. It will be remembered that in our original review we took exception to the introduction of the Potsdam scale as a standard, and we are glad to point out this instance of the cosmopolitan character of the work. The Spectra of Sun-spots, of Faculæ, of the Sun's limb, and of the Corona are fully treated of, the chapter on the Sun winding-up with—"From this brief statement of the most important results of the spectroscopic analysis of the Sun's light the reader can easily see how much careful work needs to be done, as well in the way of new observations as in a fresh discussion of existing data. This applies particularly as to the density of the solar atmosphere derived from the appearance of the bright lines occurring at the Sun's limb. It may be assumed that the temperature of the upper parts of the chromosphere is not so high as to be incomparable with artificial terrestrial temperatures. A direct proof of the minute density of the solar atmosphere at elevations to which the prominences rise has been furnished by several comets which have rushed through this region at perihelion and whose orbits show no disturbances. . . . We cannot, therefore, avoid the conclusion that the mighty convulsions within the solar atmosphere involve masses which are utterly infinitesimal as compared with the mass of the whole Sun. . . . The solar theory of the future must be based upon this conception. This done, the explanation of the great velocities occurring in the solar atmosphere will present no difficulties, perhaps even without the assumption of electric phenomena."

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* 'A Treatise on Astronomical Spectroscopy—being a translation of "Die Spectralanalyse der Gestirne" by Dr. Scheiner.' Translated, revised, and enlarged, with the co-operation of the Author, by Edwin Brant Frost, M.A., Assistant Professor of Astronomy in Dartmouth College. Ginn and Co.: Boston and London.

The space devoted to the spectra of the planets is necessarily small, and of this Jupiter takes the lion's share. Prof. Keeler's observations of Saturn's Rings are quoted, as proving the non-existence of an atmosphere about them, since he failed to detect the slightest trace of the dark band in the red. Then follow the spectra of Comets and Nebulæ, a list of Planetary Nebulæ discovered with the spectroscope being given.

Star-spectra are described under the following heads, which we give in full:—

Type I.—Metallic lines very faint and fine, or are invisible, and the blue and violet portions conspicuous by their intensity.
- (*a*) In addition to the faint metallic lines, the hydrogen lines are present and conspicuous for their breadth and intensity (Sirius, Vega).
- (*b*) Metallic lines few in number, faint or invisible, and the hydrogen lines lacking (β, γ, δ, and ϵ Orionis).
- (*c*) The hydrogen lines and D_3 are bright (β Lyræ, γ Cassiopeiæ).

Type II.—Metallic lines very prominent, violet and blue portions not conspicuous, weak bands in the less refrangible portions.
- (*a*) Numerous metallic lines, intense in yellow and green. Hydrogen lines strong, but never so broad as in Type I. *a* (Capella, Arcturus, Aldebaran).
- (*b*) Bright lines in addition to the dark lines and the faint bands (T Coronæ and Wolf-Rayet stars).

Type III.—Spectra throughout which, in addition to dark lines, numerous dark bands are distributed, the more refrangible portions being strikingly faint.

(*a*) In addition to the dark lines, bands are present, the most conspicuous being dark and sharply defined towards the violet, but faint and indistinct towards the red (*α* Herculis, *α* Orionis, *β* Pegasi).

(*b*) Dark and very broad bands, most prominent towards red and shading off towards violet (Nos. 78, 152, 270 in Schjellerup's Catalogue).

Following this we have "New or Temporary Stars," in which "Nova Aurigæ" and its created "Theories" are dealt with at great length; Distribution of Stellar Spectra; Abnormal Spectra; Spectra of Aurora and Zodiacal Light. Then come "Displacements of spectral lines," from which we pass to "Rotation of the Sun," "Motion in the line of sight," and "Spectroscopic Binaries"—a very fascinating chapter, and full of what may be termed the newer and greatly improved methods, and is not the least valuable chapter in the book.

Part IV.—The Spectroscopic Tables given are—

(i.) Rowland's new table of standard wave-lengths;
(ii.) Abney's wave-lengths of lines in the ultra-red portion of the solar spectrum;
(iii.) Kayser and Runge's wave-lengths of selected lines in the arc-spectrum of iron;
(iv.) A catalogue of stars of Classes III. *a* and III. *b*;
(v.) Young's partial revision of the chromospheric lines.

A most valuable appendix is the "Bibliography of Astronomical Spectroscopy," which is given under ten heads, such as "Spectra of Planets," "Spectroscopic Apparatus," &c.

A complete Index to a most complete work fittingly comes next, and we are only sorry that our limited space does not permit of a fuller description.

THE TRIANGULATION OF SIXTEEN STARS IN THE PLEIADES BY MEANS OF THE FRAUNHOFER HELIOMETER AT THE OBSERVATORY OF GÖTTINGEN *.—In the first volume of the 'Astronomische Untersuchunge,' Bessel gives measures of the 52 brightest stars in the group of the Pleiades with the new 6-inch heliometer of the Königsberg Observatory. Re-measures of these stars are of the greatest interest, both as throwing light on the question of a physical connection between the components of the group, and on the instrumental constants and errors of the heliometers which were used in the Transit of Venus expeditions of 1874 and 1882. The first of these points of interest has been considered by Dr. Elkin in his measures with the Yale heliometer in Newhaven. For the second, Dr. Leopold Ambronn undertook, in the years

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* Astronomische Mittheilungen von der K. Sternwarte Göttingen, Theil iii.

1889, 1890, and 1891, a triangulation of sixteen stars, embracing those as faint as the 7th magnitude, with the Fraunhofer heliometer at Göttingen. Each star was connected with at least three others, and all distances were excluded which exceed 40′. The intervals $17b - \eta$ and $\eta - 27f$ were repeatedly measured to find the effects of temperature and change of scale value. By the kindness of Herr Auwers the instrumental constants used in the Transit of Venus expeditions were supplied. These values have been partly employed unchanged in the reductions, but new constants were calculated where it appeared desirable. The probable error of a single measure varied from $\pm 0^{R}{\cdot}0014$ to $\pm 0^{R}{\cdot}0106$, or $0''{\cdot}024$ to $0''{\cdot}190$, the greatest errors generally occurring with the larger distances measured. Dr. Ambronn finally compares his results with those of Dr. Elkin, on the movement and direction of motion of the individual stars in the group relatively to η Tauri. He concludes that all the components of the Pleiades are not physically connected, but that it may be divided into smaller groups whose individual stars are united. Thus the stars *e* and *c* have a common similar motion relative to η of about $0''{\cdot}5$ in the direction 77°, but *s* has a motion of $1''{\cdot}42$ in the direction $122^{\circ}{\cdot}5$. The number of stars measured with the heliometer is too small for a full discussion of this question.

Positions apparentes des taches solaires photographiées à Poulkova par B. Hasselberg dans les années 1881–1888.—M. Belopolsky, with the assistance of M. Morine, has measured, reduced, and tabulated the results of this series of solar photographs.

In 1881	the number	measured and	reduced is	41.
1882	„	„	„	98.
1883	„	„	„	55.
1884	„	„	„	85.
1885	„	„	„	114.
1886	„	„	„	85.
1887	„	„	„	27.
1888	„	„	„	6.

The tabulated information gives

Distance and position-angle corrected for refraction;

The true area of the surface of the spots (unity $\frac{1}{100,000}$ of the mean solar disk);

Notes and other details;

Refractions applied.

NOTES.

Comet Notes.—'Astronomy and Astro-Physics' for August contains a reproduction of a photograph of Gale's Comet taken at Mount Hamilton on May 5. The tail appears as a slender straight ray, getting broader and fainter at the end away from the head.

A second, fainter tail, making an angle of 6° with the first, leaves it at a point about one third of its length away from the head. From the same number we learn that Tempel's Comet was under observation at Mount Hamilton in the middle of July, and promised to be visible for some time longer. It was very faint in the 12-inch, ½′ diameter, without central condensation. A. C. D. C.

VARIATION OF LATITUDE.—Prof. T. C. Mendenhall communicates to the 'Astronomical Journal,' No. 323, an abstract of the results of observations made by Prof. G. Davidson to determine the latitude of San Francisco during the period May 1891 to August 1892. It will be remembered that this is one of the stations occupied by expeditions organized by the U.S. Coast and Geodetic Survey, whose object was to make observations to detect the variation, if any, of latitude. The results from the other two stations—Waikiki, near Honolulu, and Rockville, near Washington—have already been published. The figures given below show with what accuracy Dr. Chandler's theory is satisfied by actual observation at San Francisco.

Using the results of the observations to find the constants, Dr. Chandler's formula appears as follows:

$$\phi = 37^\circ\ 47'\ 28''\cdot334 + 0''\cdot171 \sin(0\cdot83526\,t + 3^\circ\cdot7) + 0''\cdot074\,(\sin 0\cdot98563\,t + 20^\circ\cdot5),$$

where t is the number of days from 1891 Jan. 0, and hence the computed latitude of the station on 1891 Oct. 31 would be 37° 47′ 28″·12, on 1892 May 12, 37° 47′ 28″·52. The values on these respective dates found from observation are 37° 47′ 28″·10 and 37° 47′ 28″·51. Similar comparisons are given for other dates, but these two chosen for illustration are those of the maximum and minimum values of the formula. The differences between computed and observed values have a range of 0″·23 during the period.

THE LOWELL OBSERVATORY.—In a note in our May number it was stated that an American expedition to Arizona was being organized for the purpose of observing Mars this summer. More recent information explains that this refers to the establishment of the Lowell Observatory at Arizona, near the town of Flagstaff, long. 112° W., lat. 35° N., at an elevation of 7300 feet above the sea. The observatory, the building of which is almost completed, consists of an equatorial room—containing a telescope of 18 inches aperture for visual and spectroscopic work, with a twin telescope of 12 inches aperture to be used for photography—and a computing-room, with sleeping apartments. A six-inch portable equatorial completes the equipment.

This establishment is subsidized by Mr. Percival Lowell, of Boston, and is not, as has been stated, an offshoot from the Harvard College Observatory. The director is Prof. W. H. Pickering, who, with his colleague on the Lowell staff, is on leave of absence from Harvard.

Connected with this observatory, Prof. E. S. Holden, in the latest number of the 'Publications of the Astronomical Society of the Pacific,' makes some severe but courteous remarks, with which we thoroughly agree. At a meeting of the Boston Scientific Society, Mr. Lowell gave a description of the new observatory and expounded a plan of campaign, which implied, to put it briefly, that the purpose of the observations to be made was to discover if any of the other planets were inhabited by creatures like ourselves, and his remarks also implied that the answer to this question was not far distant.

We do not mean to say that this is the whole substance of the paper: read in another light, it states that the telescope is to be devoted to physical observations of the surface of Mars, and we fully believe that it is in this light that Prof. W. H. Pickering will interpret his warrant of office; but we do join Prof. Holden in his protest against attempts to popularize Astronomy by holding out hopes of solution of problems dear to the public mind, but not likely to be realized. Astronomy is strong enough to stand without public favour gained by such means.

We are also at one with Prof. Holden in another objection he raises in the same article. He refers to the practice of communicating the results of one or a few nights' observations, translated freely and into very popular language, to the public press. He gives instances of newspaper reports during the Mars *boom* of 1892, in which facts concerning the geography and climate of Mars were stated with a certainty about equal to that pertaining to similar facts about Central Africa, and which were read with astonishment by the Lick observers, who were keeping a constant watch on the planet at the time with the large telescope. This practice, while perhaps creating a sort of public interest in the science, has certainly the effect of detracting in popular opinion from more valuable but less sensational labours of other observers.

Since the above note was written the August number of 'Astronomy and Astro-Physics' has been received, containing the report of the first observations at Arizona—observations of the surface of Mars made by Mr. Lowell from May 31 to June 24 of this year. Mr. Lowell was able to follow day by day the disintegration of the south-polar snow-cap, he infers, by melting, from the fact that the surrounding dark marking, which is perhaps a sea, gradually widened, and also he saw a rift in the snow appear and enlarge till it joined the polar sea, as one would expect to see in the breaking up of a snow-field.

A special feature noted by Mr. Lowell was the bright band round the edge of the disk extending inwards to a considerable distance; he is disposed to attribute this not to cloud but simply to atmosphere, which is seen at this region of the planet by reason of its thickness.

Further, Mr. Lowell saw Schiaparelli's canals, and, as evidence of the good atmosphere at Arizona, he says "two months and a half before the summer solstice of Mars' southern hemisphere." One canal, probably the Cerberus, he saw very broad and once glimpsed it double; but he gives these observations with some reservation.

To sum up Mr. Lowell's observations. He has seen the polar snow melt, and the water pouring towards the equator submerge the *islands*; and, in conclusion, he says:—"So much for the positive evidence of the circulation of water as water upon the planet. The evidence of its circulation as cloud is negative. There is no sign of cloud apparently at this season. Although the air is charged with vapour it does not condense into cloud or fall as rain or snow. Even occasional indistinctness of detail seems to be due to our atmosphere, not to that of Mars. At this spring season of the southern hemisphere the Martian aqueous circulation seems therefore to be chiefly a surface one of water. Here we have a *raison d'être* for the canals. In the absence of spring rains a system of irrigation seems an absolute necessity for Mars if the planet is to support any life upon its great continental areas."

MAGNETIC STORM.—A rather sharp but short magnetic storm occurred recently. At 5 o'clock on the morning of Friday, July 20, the needles registering all three elements experienced a sharp deflection, and the earth-current register was similarly affected. The storm continued violently until 2 o'clock on the morning of the 21st, the range of variation of the declination-needle extending over an angle of 1° 2′, while the disturbance in the vertical and horizontal force registers was equally notable.

We give this as an instance of the occurrence of a magnetic storm without an accompanying large sun-spot. The spots visible on the Sun at this time were fairly numerous, but not by any means of large size; the total area of all of them would not compare with that of the spot of February last, when the variation in the magnets was not more extensive, although longer continued than in the present case.

THE characteristic phenomenon of Harvest Moon this year will be very pronounced, as it happens that on the day of full Moon, September 14, the ascending node of the Moon's orbit will be only 1° 35′ from the vernal equinox. This does not differ much from the most favourable circumstances for the diminution of the retardation of the Moon's rising, which occur when the node is exactly at the equinox. The difference of mean time of moonrise on successive nights about the time of full Moon will be about 10½ minutes.

PUBLICATIONS OF THE ROYAL GEODETIC INSTITUTE OF PRUSSIA (Polhöhenbestimmungen im Harzgebiet, 1887–1891).—A series of observations for latitude determination undertaken by the Royal Geodetic Institute of Prussia during 1887–91 in the Harz Mountains. There were 20 stations, and the results of observations (pairs above and below pole) are tabulated under each station. Great care seems to have been taken to free the observations from systematic and personal errors.

UEBER DEN VIERFACHEN STERN ζ CANCRI (H. SEELIGER).—Mr. Burnham's criticisms on "Invisible double stars," and more especially his remarks on the system ζ Cancri, have induced Prof. Seeliger to collect the recent observations of this interesting group and treat them in accordance with his method published in the two works 'Untersuchungen über die Bewegungsverhaltnisse in dem deei-facher Sternsystem ζ Cancri' (1881) and 'Fortgesetzte Untersuchungen über des mehrfache Sternsystem ζ Cancri' (1888). The result bears out his previous deductions. The pamphlet is a reprint "Aus den Sitzungsberichten der mathematisch-physikalischen Classe der K. bayer. Akad. d. Wiss." 1894, Bd. xxiv. Heft iii., and the systematic character of the differences $p_0 - p_B$ on page 269 is very striking, and there is no reasonable doubt, whatever be the cause, that the star C has an undulatory motion in about 18 years.

PROF. SCHUR has re-determined the parallax of ψ^5 (56) Aurigæ, and finds

$$\pi = +0''{\cdot}106 \pm 0''{\cdot}054.$$

The observations, extending from 1890 Oct. 9 to 1892 March 25, were made with the heliometer at Göttingen. A previous determination with the 6-inch Strassburg refractor gave

$$\pi = -0''{\cdot}111 \pm 0''{\cdot}034.$$

Prof. Schur took two comparison stars, B.D. +43°·1590 and B.D. 44°·1538. The comparison star used at Strassburg was not one of these.—*Ast. Nach.* 3243.

No doubt many of our readers have heard of the Devonshire Astronomer, Mr. Langdon, whose death we regret to record. Mr. Langdon, Station-master of Silverton, on the G.W.R., became interested in astronomy some thirty years ago, and being possessed of mechanical ability made in his spare hours an 8-inch silver-on-glass equatorial, grinding the mirror with a machine constructed by himself. He contributed to the 'Monthly Notices' in 1872 a paper on "The Markings on Venus." His death occurred on July 18.

ANCIENT GREEK ASTRONOMY.—In reference to his letter in our June number (p. 208) on the views of the ancient Greek philosophers respecting the form of the Earth, Mr. Lynn requests us to state that he is aware that Plutarch (De Placit. Phil. lib. iii.) ascribes to Anaximander the belief that the Earth was like a stone pillar (*λίθῳ κίονι τὴν γὴν προσφερῆ*), but as he was of the Milesian school, succeeding Thales, who, according to Plutarch himself, taught the sphericity of the Earth (*σφαιροειδῆ τὴν γῆν*), the statement of Diogenes Laertius is probably to be preferred.

Mr. Espin announces, in Circular No. 39 from the Wolsingham Observatory, that the star DM. +50°,2251, R.A. $16^h\ 1^m{\cdot}5$, Decl. +50° 47′, is variable.

Our readers will learn from our advertisement pages that the well-known firm of Messrs. Cooke and Sons have established offices in London in addition to their works at York.

Miscellaneous.

The recent meeting of the British Association at Oxford was an almost unqualified success. It was no doubt a considerable disappointment to many that the Sheldonian Theatre was built of stone and not of india-rubber or other elastic material, and that consequently its capacity was limited; but the limitation was a generous one after all, and nearly 2500 people followed Lord Salisbury's brilliant Address with an interest amounting to enthusiasm. It would be difficult to imagine a more imposing spectacle for the ceremony. In the first place, the Sheldonian has a very beautiful interior, and naturally appeared to the best advantage when densely packed by a gaily dressed throng—in which the most learned Doctors with their scarlet robes were not the least conspicuous. The procession of the Chancellor to his throne, and his abdication to take the chair of the President of the Association at the opposite end of the Theatre, were most dramatic incidents with which to open the proceedings; and few things more dramatic can have occurred in the history of the Association than those which marked the close, when Prof. Huxley, one of "the Old Guard of Darwin," so vividly contrasted the state of present opinion with that which was made manifest when the Association last visited Oxford in 1860.

With the view, perhaps, of distributing the dramatic incidents of the meeting throughout the week, Lord Rayleigh and Prof. Ramsay kept their sensational announcement of the discovery of a new gas in the atmosphere until the Monday. Even then no formal intimation of a paper appeared in the Journal, but it was whispered about that something was going to happen in Section B; and the rumour spread so fast and wide that the lecture-room was crowded to receive the discoverers. The President of the Section announced, amid hearty applause, that Lord Rayleigh had a communication to make; and he accordingly stated, very briefly and clearly, that a discrepancy between the density found for the nitrogen in the atmosphere and nitrogen chemically obtained from its compounds had led him to examine atmospheric nitrogen by sparking it with oxygen and thus removing portions of it which must be chemically pure nitrogen. The density of the residue gradually rose in value from 14 to nearly 20, and it became clear that there was a hitherto unsuspected gas in the atmosphere to the almost incredible proportion of one per cent., of density about 20, and with a spectrum of its own. Lord

Rayleigh was careful to call it merely a "new gas," but some of his hearers were more sanguine and claimed it as a new element, which would fill a gap in Mendeléeff's periodic table.

It was difficult for the physicists to repress a little chuckle of exultation at the fact that a chemical discovery had been made by a physicist. "It's the case of the little boy with a bent pin catching fish when the elaborate tackle of the angler fails," said an eminent mixed-mathematician. The analogy is not, however, quite satisfactory, and might indeed be turned end for end; for the said elaborate tackle may be taken to represent the scientific methods of quantitative analysis, and the bent pin the ruder and somewhat haphazard methods by which other discoveries of elements have been made. The present discovery may be classed in type with that of Neptune as opposed to that of Uranus; its magnitude depends of course largely on further confirmation of the elemental character of the new gas, though in any case the presence of a new gas in such large quantities in our atmosphere is a matter of the first importance.

There was curiously little Astronomy at the Meeting. Prof. Förster of Berlin, who received an honorary degree, read an interesting note on the variation of latitude, giving the results of the special observations for its detection at Berlin, Honolulu, and elsewhere. More than a complete revolution of the pole has now been observed, and accordant as are the results obtained, they only point out the necessity for continued and systematic observation. The matter is to be brought before the Geodetic Association at its next meeting at Innsbrück in September; and it is hoped that four stations will be organized on the same parallel of latitude (within 5′), and in longitudes differing as nearly as possible by 90° to make special observations for latitude. England is not at present a member of the Association, which numbers 29 nations. It would, however, seem desirable that, with an item of such international importance as this added to the programme of the Association, we should reconsider the question of membership. In any case those who heard Prof. Förster's paper will remember also some weighty words which fell from the Treasurer of the Royal Society, the significance of which the President of the Section was not slow to point out.

Dr. Roberts showed some of his beautiful photographs of spiral and elliptic nebulæ, which were thoroughly appreciated; and Prof. Turner read a brief note on some photometric measures of the Corona of 1893, pointing out that the "extension" was traceable on the photographs much further from the limb than is generally supposed, and suggesting additional observations of the extension by the members of the Association who might visit Norway in 1896. It should be remarked the Association was thoughtful enough to defer its second visit to Canada until 1897, although a warm invitation had been received from Toronto for 1896; and those who go to Norway will thus not miss the chance of going to Canada.

Concerning this same visit to Norway, it is to be feared the social conditions on the north-east coast are not so favourable as might be supposed from reading Baedeker. Col. Burton Brown, an experienced traveller and eclipse observer, has recently paid a visit to Norway and thoroughly examined the locality, and he will give a detailed account of his exploration to the Royal Astronomical Society at their Meeting in November. But the general tenour of the result may be gathered from the fact that he strongly deprecates any ladies venturing into these regions. The population consists of a few Lapps, and such trifles as sleeping accommodation, attendance, and perhaps food, suitable for ladies, must be taken with them. It thus seems probable that those who wish to make more or less of a pleasure-excursion must confine themselves to the west of Norway, where the eclipse will be still visible, though with a low Sun and short duration.

It would be a thoroughly useful piece of work to plot down on a large scale map the limiting lines for different durations of totality—say every ten seconds, and also those for every 5° of Sun's altitude at totality. The Superintendent of the 'Nautical Almanac' has given in a Supplement equations from which such lines could readily be calculated, and their graphical representation would convey at a glance information of the greatest importance for selecting stations either for a scientific expedition, or for merely seeing the wonderful spectacle afforded by a Total Solar Eclipse.

One of the members of the British Association, of astronomical proclivities, summed up his experiences at Oxford in a remark of such charming simplicity as to deserve record:—"I have spent the most delightful week I ever remember," said he, "and I have got photographs of all the most important sundials in Oxford." The pictures did not, however, reveal any mome-raths or borogoves or other creatures mentioned by Humpty-Dumpty to Alice.

A very good instance of the "artistic license" which characterizes most appearances of the heavenly bodies in pictures was afforded the other day by the periodical which the Liverpool magistrates have driven from our railway book-stalls. In a plate purporting to give an idealization of "Diana," a beautiful female figure was represented using the crescent moon as a bow. The arrow, which should indicate precisely the direction of the illuminating Sun, was pointed upwards, so that the Moon and stars were apparently visible in the sky, while the Sun was high in the heavens.

Such license is of course not peculiar to Art. Literary instances would make a very interesting collection. "He had taken a powerful refracting telescope with him," I read in a clever novel the other day, "through which he gazed at the starry heavens during the long nights; at the planets with their moons and rings, on which in winter white spots are visible, whilst in summer a red light surrounds them." A fairly accurate description of the lunar surface follows, but astronomers are perhaps not aware that "nothing is there except the souls of those who violently separated themselves from their body to get rid of its load. There they are at peace; they feel nothing, do nothing, know neither sorrow nor joy, gain nor loss; there are neither air nor water, winds or storms; no flowers or living creatures, no war, no kisses, no heart-throbs—neither birth nor death; only nothing," and perhaps memory? There is perhaps no wonder that the particular observer in question "detested the Moon, and never studied the shining points in boundless space through his glass until the Moon had set." The importance of moonless nights for observing has been generally admitted, but this is a novel reason for it.

As I have quoted so far, I may add the description of "one of those celestial phenomena which are all but unique in the annals of astronomy. A comet returning after centuries of absence appeared in the sky. Timar said to himself 'This is my star; it is as lost as my soul, its coming and going are as aimless as mine, and its whole existence as empty and vain a show as is my life.' Jupiter and his four moons were moving in the same direction as the comet; their orbits must cross. When the comet approached the great planet its tail seemed to divide; the attraction of Jupiter began to take effect. The great star was trying to rob its lord the Sun of this vaporous body. The next night the comet's tail was split in two. The next night the largest and most distant of Jupiter's moons drew rapidly near. 'What has become of my star?' asked Timar. The third night the nucleus of the comet had grown dull and began to disperse, and Jupiter's moon was close to it. The fourth night the comet had been divided into two parts, there were two heads and two tails, and both the starry phantoms began in separate parabolic curves their aimless flight through space. So 'this' occurs in the heavens as well as on earth?"

Perhaps I may be forgiven for italicising a phrase in a final extract from this really excellent novel, which almost immediately follows the above:—"Keep a watchful eye on those who seek to fathom the secrets of nature *without a technical education.* Hide away the knife and the pistol every night, and search their pockets lest they carry poison about them, for there are hundreds of motives for suicide, but the most potent are to be found among those who give themselves up to scientific research." I think it is only fair to italicize the above words; for professional astronomers are notoriously long-lived, and yet it is strange that it should have been left to me to draw attention to the importance of the technical education. Would it not be only kind to warn the author of his danger? H. H. T.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 219. OCTOBER. 1894.

Notes on Mars in 1894.

In all probability Mars will be receiving more attention from astronomical observers this year than in any previous apparition of the planet. Hence the following notes may be of interest, not only for purposes of comparison, but also as directing attention to certain important features of Mars and pointing out their present condition.

The Canals.—Although the existence of numerous narrow dark streaks, well known by the name of "canals," is now well established, yet there still remain many important points in connection with these enigmatical features to be cleared up. How far is the visibility of the canals in different parts of the planet affected by seasonal changes? Their duplication, when does it occur? How long does it last? How does it occur? And again, how far is it subject to seasonal changes? These and other important questions can only be settled by numerous careful observations extending over a number of years.

Having had some success in observing the canals in 1890 and 1892, in both of which years the altitude of the planet was very low, I was anxions to see how they would appear when Mars was high up and well situated. Observations were commenced in the latter part of August, when the canals were seen with greater ease and distinctness than I had ever expected, or hoped for. The plainer ones are conspicuous, whilst even the *average* canal cannot be called really difficult. About thirty of the canals have already been seen, most of them upon more than one night, though only about two thirds of the planet have yet been examined. The following call for particular notice:—

Ganges.—Seen double on Aug. 29. Although dark and plain, this canal is, however, not nearly so dark and intense as it was in 1892, nor is the duplicity so plain. Lacus Lunæ was also suspected double in the same direction, or in continuation of Ganges.

Gehon.—Seen plainly double on Aug. 29 with power 320 on a 6½-in. Calver reflector. Mr. B. E. Cammell, observing at

Wokingham on the same night with a 12½-in. reflector, but under less favourable conditions, found this canal fairly easy, and also suspected it to be double, though he could not quite satisfy himself as to this. A component runs from each of the two bays, or inlets, of Dawes Forked Bay. The interval between the two seemed slightly greyish or dull-looking. This canal has only very rarely been seen double. In fact, I have only been able to find two somewhat doubtful recorded instances—one by Professor Schiaparelli in February 1882, the other by M. Guillaume in May 1890.

Orontes—Typhonius.—Narrow, but dark and plain, and apparently not quite uniform in breadth or intensity. This canal was so dark and definite on Aug. 29 that it *looked* like a great obscure rift or chasm in the yellowish reddish continent. Mr. Cammell also observed the Orontes on the same night, and noted that it was very plain. The Typhonius has a well-defined, dark, bell-shaped mouth.

Phison.—Remarkably plain, and suspected to be double on several nights.

Eunostos.—Seen plainly double on Sept. 9 and 11. It is greyish, not very dark, and the duplicity is confined to the preceding part, the following portion being narrower and single.

Cyclops.—Also seen double on Sept. 9 and 11. Like Eunostos, it is not very dark.

Cerberus.—Very intensely double on Sept. 9 and 11, appearing composed of two quite blackish-looking lines, very close together.

It will be noticed that five of the canals have been seen clearly double *, almost exactly at the date of the summer solstice of the southern hemisphere. This event occurred on Aug. 31 according to Mr. Marth.

The small dark Spots or Lakes.—Observing Mars on Sept. 1, I was surprised to see, at the point where the canals Typhonius and Phison cross each other, a minute dark spot, so dark as to appear nearly black. This little spot has been called *Sirbonis Lacus* by Professor Schiaparelli, and it appears to vary greatly in visibility. In this respect it resembles Fons Juventæ and other similar small dark spots. There is a somewhat similar but more difficult little lake in the middle of Hellas, at the point where the canals Alpheus and Peneus intersect each other, which was also visible in 1892. Presumably these little dark spots are similar to the minute black points or lakes, over forty in number, detected at Arequipa in 1892. Lunæ Lacus is probably only a larger object of the same kind.

Libya.—In some years this little continent has appeared somewhat dull-looking, particularly in its southern half. Lately it has been remarkable for its great brightness and whiteness, in which respects it has greatly surpassed the neighbouring continental masses.

West Brighton, 1894, Sept. 18. A. Stanley Williams.

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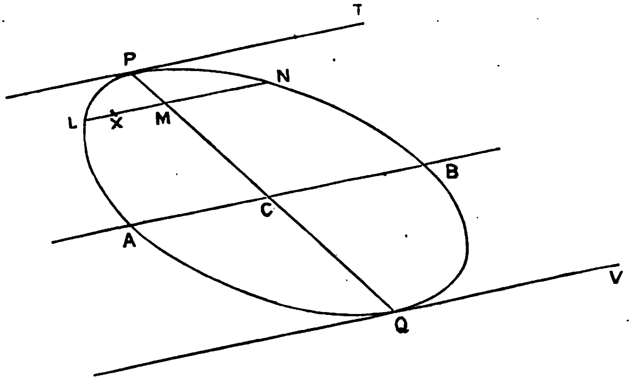
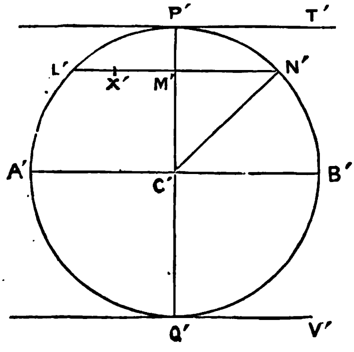
* On Sept. 23 the canal Agathodæmon was very intensely double between Lacus Tithonius and Lacus Phœnicis. The Araxes was also intensely double, but narrower and more difficult than the Agathodæmon.

A Graphical Method of determining the Duration of Totality of a Solar Eclipse at a point not on the Central Line.

In the September number of the 'Observatory' Prof. Turner pointed out that contour-lines giving the duration of totality at points away from the central line would be of service in selecting suitable stations. Now as the different ephemerides vary nearly 4 seconds in the duration at the same point on the central line (in consequence of differences in the assumed semidiameters), it is clear that this question of duration is one where great accuracy is not attainable and an approximate solution is amply sufficient. The following method is convenient in practice and, I think, of quite sufficient accuracy. Provided the Sun be not very low, the outline of the shadow on the Earth's surface is sensibly an ellipse, having its centre approximately on the central line and touching the north and south limits of totality. Let ACB be the central line, PT QV the north and south limits of totality, then we may treat PT, QV as parallel to ACB: hence PQ, AB are conjugate diameters. Let X be the point at which we wish to ascertain the duration of totality; draw LXMN parallel to AB; then duration at X : duration at C :: LN : AB :: MN : CB. Now project the ellipse orthogonally into a circle, and let accented letters denote the corresponding projected points; then P′Q′ is perpendicular to A′B′.





Now MN : CB :: M′N′ : C′B′.
And M′N′ : C′B′ :: sin $\underline{|M'C'N'}$: 1.

$$\text{Again, } \underline{|M'C'N'} = \cos^{-1}\frac{C'M'}{C'P'}$$
$$= \cos^{-1}\frac{CM}{CP}.$$

Hence duration at X = duration at C × $\sin\cos^{-1}\frac{CM}{CP}$.

Thus we get the Rules:—To find the duration at a given point within the belt of totality, express the distance of the point from the central line as a fraction of the half-breadth of the shadow-track, and find the angle ϕ which has this fraction for cosine; multiply the duration at an adjacent point on the central line by $\sin\phi$, and we get the duration required. Conversely, to find the distance from the centre line at which we get a given duration, express this duration as a fraction of that at an adjacent point on the central line, and find the angle ϕ which has this fraction for sine: then the distance from the central line of the point required is the half-breadth of the shadow-track × $\cos\phi$. The following Table gives the durations at distances from the central line of $\frac{1}{10}, \frac{2}{10}, \ldots \frac{9}{10}$ of the ½-breadth of shadow-track:—

Distance from central line.	ϕ. ° ′	Sin ϕ $\left(=\frac{\text{duration at point}}{\text{duration on central line}}\right)$.
·10	84 16	·995
·20	78 28	·980
·30	72 32	·954
·40	66 25	·917
·50	60 0	·866
·60	53 8	·800
·70	45 35	·714
·80	36 52	·600
·90	25 50	·436

Thus half of the entire belt of totality has a duration of at least $\frac{7}{8}$ of that on central line; hence it is not a matter of importance to be very accurately placed on the latter.

Strictly we should take the point on the central line which has mid-totality at the same instant as the point considered, but any neighbouring point will suffice in practice. The ephemerides give the positions of the central line and north and south limits of totality, also the durations at various points on the central line; with these data and repeated application of the above rule we can draw contour-lines indicating the loci of given durations, as suggested by Prof. Turner. I have applied this method to the case of the shadow-track across Norway in the eclipse of Aug. 9, 1896; this is not, however, a favourable case for the method, in consequence of the Sun's small altitude. The following Table gives the latitudes at which the central line, the north and south limits of totality, and the contour-lines of 75ˢ, 85ˢ, and 95ˢ duration cut alternate meridians from 12° E. to 32°. The durations on the central line are taken from the American ephemeris, those given by the 'Nautical Almanac' are about 3 seconds longer. This Table will make it easy to construct such a map of the track across Norway as that suggested by Prof. Turner.

Long. E. of Greenwich.	Central line.	N. limit of totality.	S. limit of totality.	N. line of 75ˢ duration.	S. line of 75ˢ duration.	N. line of 85ˢ duration.	S. line of 85ˢ duration.	N. line of 95ˢ duration.	S. line of 95ˢ duration.
°	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
12	66 30·5	67 20	65 49	66 59	66 7	66 50	66 17	……	……
14	67 0·5	67 49	66 19	67 30	66 37	67 21	66 46	……	……
16	67 28·4	68 16	66 46	67 58	67 4	67 50	67 12	……	……
18	67 54·3	68 41	67 12	68 24	67 29	68 16	67 37	67 56	67 53
20	68 19·2	69 6	67 37	68 49	67 53	68 42	68 1	68 26	68 13
22	68 41·9	69 28	68 0	69 12	68 16	69 5	68 22	68 52	68 33
24	69 2·7	69 49	68 21	69 33	68 36	69 27	68 42	69 16	68 52
26	69 22·5	70 9	68 41	69 53	68 55	69 47	69 1	69 38	69 11
28	69 42·4	70 28	69 1	70 14	69 15	70 8	69 21	69 59	69 29
30	70 2·0	70 48	69 21	70 34	69 34	70 28	69 40	70 20	69 48
32	70 18·2	71 4	69 37	70 50	69 50	70 45	69 55	70 38	70 3

The Sun has an altitude of 6°, 11°, 15° at longitudes 12°, 22°, 32° respectively.

I conclude by expressing a hope that none who had intended occupying posts on the N.E. coast of Norway will be deterred from doing so by Prof. Turner's note in the 'Observatory' for September. If, as is hoped, a special steamer is chartered, this will accommodate observers during their stay in these regions, and they will be quite independent of the accommodation to be found on shore. An altitude of 8°, which is all that can be obtained on the West Coast, is certainly insufficient for any useful work.

A. C. D. Crommelin.

On the Construction of Optical Glass *.

That my hearers may better understand the difficulties met with in the making of large lenses for astronomical telescopes, I will first endeavour to explain as briefly as possible the characteristics which distinguish optical glass from ordinary glass, and then the difference in the respective processes of manufacture.

This manufacture, very little known, was initiated at the beginning of the century by Guinand, the founder of our firm; the methods were improved by my learned predecessor, Charles Feil, and I myself have done what I have been able to develop the industry.

It is more by the method of working than by the material itself that the making of optical glass differs from that of ordinary glass. When a piece of ordinary glass—the purest that can be found—is examined, at the first glance it will appear of perfect clearness; but if the same piece be looked at at a certain angle or through its edge, there will be seen a kind of thready mass resembling nothing so much as a piece of picked-out tow; this will often be seen in parallel streaks when a glass casting is looked at through its edge, but is invisible when the plate is looked at normally. Frequently, when looking through a window, the passers-by in the street suddenly appear deformed and their features distorted; this illusion is due to the faults in the glass of which I speak. These imperfections must be eliminated from optical glass, which ought to be homogeneous in every part, so as to allow the rays of light to pass without any deviation.

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* A translation of an address delivered by M. Mantois before the Astronomical Society of France, 1894, Feb. 7.

In ordinary glass-works the kilns, which are kept heated continuously, either contain a number of crucibles or else each forms a great basin; in either case the vitrifiable matter is placed in the receptacle, and at the end of a certain time is found sufficiently melted and refined to proceed to blowing or casting. In the latter case the crucibles, containing from 500 to 800 kilos of glass, are carried by huge iron tongs to casting-tables, where the glass is rolled and levelled to the required thickness.

It would seem that this simple process would suffice for the production of glass for lenses; but the method is not applicable, owing to the innumerable striations that the casting invariably leaves in the masses. Whatever be the method of treating the glass, whether it be blown or cast, it is put back in the oven to be re-baked, where the temperature is lowered more or less slowly, according to the forms and dimensions of the articles.

In making optical glass, the kilns contain only one crucible at a time. The process is as follows:—

The kiln being cold and open, an empty crucible, made of infusible clay, perfectly dry, in the form of a large cylinder about a metre in height, and ending in a dome, having on top an opening like a little door, called the *mouth*, is put in. The kiln is then blocked up, so as to leave only the mouth of the crucible attainable. Through this the materials are to be introduced and the operation of mixing performed.

The capacity of the crucible varies from 600 to 1000 kilos, according to the density of the glass. Equal-sized crucibles contain about 600 kilos of crown or 1000 kilos of flint. These are the two great classes generally adopted for optical glass. In spite of compositions very varying, one may say that crown-glass is made of silicate of potash and of soda or lime, while flint-glass consists of silicate of potash and lead. The crucible having been placed and blocked in the kiln, is slowly warmed, the greatest precautions being taken to prevent its breaking; starting with a slow fire, which is gradually increased in power, the crucible becomes white hot after about thirty hours.

We now begin to put the ingredients in this receptacle, and by small quantities, it must be noted; for if a quantity of sand, soda, boric acid, lime, &c. were to be put in at once, there would be a boiling over, and the greater part would escape and be found as a casting in the kiln. It is necessary, therefore, to wait after the first supply until the boiling has taken place before introducing the second. It takes from 15 to 18 hours to thus fill the crucible by these small additions.

Eight or ten hours after the last addition, the crucible being completely full, the period of refining begins. Up to this the matter has been vitrified, but is full of bubbles, and resembles in some degree the lather of soap. The glass now is heated to a degree as high as possible, according to its nature, even, I may say, sometimes to excess. I say to excess, for, for certain very hard crown, we reach temperatures which touch 1600 or 1800 degrees; it is fortunate when the crucibles are not destroyed under the influence of the fire, for at these temperatures sometimes bricks most impervious to heat are themselves melted, and kilns and crucibles rendered useless.

This period of heat varies from 20 to 30 hours; at this stage samples of the glass are taken in little ladles. These samples cool rapidly in the shape of half-balls, which are examined by the magnifying-glass in different conditions of light: thus one can judge of the state of refinement that the glass has reached. It is only after having taken several samples without bubbles that we stop, or at least suspend, the stage of the great firing. The crucible is then opened, and the molten glass is skimmed to rid it of the impurities which rise to the surface.

We now proceed to the most important operation—the mixing. It is necessary to mix every part most thoroughly. The glass is in constitution analogous to an alloy; silicates of definite composition are formed, held in dissolution in basic silicates, which oppose the crystallization of the former, so nothing is less easy than to avoid the separation of these heterogeneous elements and to stop the liquefaction which causes the streaks. To obtain complete homogeneity it is necessary, by slow stirring, to thoroughly mix the glass, so that, after a certain number of hours, when it solidifies, it may have the same chemical composition and the same density throughout its mass.

To this end we introduce into the crucible a cylinder of non-fusible clay in the shape of a hook, previously made white hot in a special kiln. This hook has for a handle a straight iron bar hanging vertically by a chain from a point above the kiln; the bar is in turn furnished with a wooden handle at right angles; by this arrangement it is possible to give the mixer a to-and-fro motion, or a movement of rotation when the glass in the pot is as fluid as water. For this work—very laborious, as may be supposed—a relay of four men work for five minutes, each in turn following our personal instructions. It is, in fact, only experience which enables us to judge what kind of stirring is necessary for such and such kind of glass. The men are not able to continue this work for more than five minutes without interruption, especially during the early part of the mixing, when the heat is so great that they are obliged to wear special gloves and sleeves and the sweat from their foreheads trickles into their eyes, so as to blind them.

If after a period of mixing, say an hour or two, bubbles reappear in the mass of glass, we stop the mixing, withdraw the agitator, block up again the crucible, which we begin to heat afresh, until the samples taken out show that the gas has disappeared. But if all is well and no bubbles reappear, the stirring is continued for 10 or 15 hours, during which time the temperature is gradually lowered by diminishing the fire.

After a few hours' mixing the glass begins to thicken, and becomes more and more doughy until it acquires a consistence so that it is difficult to move the agitator.

When there is no longer any fear of an increase of temperature, which would cause a re-separation of the elements of the glass, the agitator is cautiously withdrawn and the fires completely put out. For five or six hours the whole is allowed to cool rapidly until the surface of the glass, when struck by an iron, gives out a sharp sound; the kiln is then unblocked. After having obtained complete solidification in these five or six hours of rapid cooling, it is now necessary to re-bake the mass to effect the tempering. A block of glass cooled too rapidly when taken from the kiln is in such a state of molecular tension that, with the slightest blow, it would fall into a thousand pieces, like a Prince Rupert's drop. The re-baking is done to stop this tension as much as possible.

To effect slow cooling (after this second heating) we block up the kiln completely and isolate it, so that no current of air can strike it. For ordinary kinds of glass this cooling lasts for from 10 to 15 days; in special cases, in making blocks of large size, I have continued the cooling for a month or even six weeks. At the end of this time, the kiln being completely cold, the crucible and the glass within is broken up into pieces more or less large.

The pieces of glass thus separated are each examined by special workmen by the aid of a magnifying-glass. We have succeeded in mixing the glass in a manner almost complete, but unfortunately, during the progressive solidification, there are sometimes formed the thready strata spoken of at the beginning. In fact, it is easy to understand that the walls and surface of the crucible cool quicker than the centre and bottom, and that during the last hours of the stirring the outer parts and the surface, having become partially solid, do not follow the movement of rotation of the agitator as do the hotter parts; this causes an internal action in the glass, which produces a quantity of very fine threads within a distance of about 10 centimetres from the walls of the cylinder.

Thus, in spite of all our care, we often find in smelting pieces of glass spoilt by striations, representing in the bulk 50 per cent. of the whole mass. The pieces are studied each by itself in a special light, to enable us to easily discover the flaws, which are taken out either by a hammer or by grinding; when pronounced free from defects, the pieces are sorted according to size and placed in moulds of infusible clay, which are in turn placed in the moulding-furnace.

These furnaces, unlike the fusing-kilns, are only heated to a relatively low temperature, that is to say, not passing 800° or 900°. In these furnaces the blocks of glass are warmed slowly, so as to soften and shape themselves to the mould. This operation requires some watchfulness, for it is necessary to soften the glass, but at the same time to guard against allowing it to fuse; for if the chemical process recommenced, and hence the boiling, all would be lost.

After this moulding of the glass it is re-baked, with precautions similar to those adopted in the case of the original crucible. After the slow cooling the plates are taken from the moulds, their edges polished, again examined, and given to the optician.

In the Avu Observatory *.

The observatory at Avu, in Borneo, stands on the spur of the mountain. To the north rises the old crater, black against the unfathomable blue of the sky. The slopes plunge steeply downward into the black mysteries of the tropical forest beneath. The little house in which the observer and his assistant live is about fifty yards from the observatory, and beyond this are the huts of their native attendants.

Thaddy, the chief observer, was down with a slight fever, and his assistant, Woodhouse, paused for a moment in silent contemplation of the tropical night before commencing his solitary vigil. He thought, perhaps, of all the possibilities of discovery that still lay in the black tangle beneath him; for to the naturalist the virgin forests of Borneo are still a wonderland full of strange potentialities. He carried a small lantern in his hand, and its yellow glow contrasted vividly with the infinite series of tints between lavender-blue and black in which the landscape was painted.

The night was very silent. Now and then voices and laughter came from the native huts, or the cry of some strange animal was heard from the midst of the mystery of the forest. Nocturnal insects appeared in ghostly fashion out of the darkness, and fluttered round his light. His hands and face were smeared with ointment against the attacks of the mosquitoes.

Even in these days of celestial photography, work done in a purely temporary erection, and with only the most primitive appliances in addition to the telescope, still involves a very large amount of cramped and motionless watching. He sighed as he thought of the physical fatigues before him, stretched himself, and entered the observatory.

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* It is so seldom that an Observatory is chosen as the scene of a thrilling episode that we venture to reproduce *in extenso* a short romance which appeared in the 'Pall Mall Budget.' We do not know whether this is founded on fact, but the incident is certainly not beyond the bounds of probability.

The reader is probably familiar with the structure of an ordinary astronomical observatory. The building is usually cylindrical in shape, with a very light hemispherical roof capable of being turned round from the interior. The telescope is supported upon a stone pillar in the centre, and a clockwork arrangement compensates for the earth's rotation and allows a star once found to be continuously observed. Besides this, there is a compact tracery of wheels and screws about its point of support, by which the astronomer adjusts it. There is, of course, a slit in the movable roof which follows the eye of the telescope in its survey of the heavens. The observer sits or lies on a sloping wooden arrangement, which he can wheel to any part of the observatory as the position of the telescope may require. Within it is advisable to have things as dark as possible in order to enhance the brilliance of the stars observed.

The lantern flared as Woodhouse entered his circular den, and the general darkness fled into black shadows behind the big machine, from which it presently seemed to creep back over the whole place again as the light waned. The slit was a profound transparent blue, in which six stars shone with tropical brilliance, and their light lay, a pallid gleam, along the black tube of the instrument. Woodhouse shifted the roof, and then proceeding to the telescope, turned first one wheel and then another, the great cylinder slowly swinging into a new position. Then he glanced through the little companion telescope, the finder, moved the roof a little more, made some further adjustments, and set the clockwork in motion. He took off his jacket, for the night was very hot, and pushed the uncomfortable seat to which he was condemned for the next four hours into position. Then with a sigh he resigned himself to his watch upon the mysteries of space.

There was no sound now in the observatory, and the lantern waned steadily. Outside there was the occasional cry of some animal in alarm or pain, or calling to its mate, and the intermittent sounds of the Malay and Dyak servants. Presently one of the men began a queer chanting song, in which the others joined at intervals. After this it would seem that they turned in for the night, for no further sound came from their direction, and the whispering stillness became more and more profound.

The clockwork clicked steadily. The shrill hum of a mosquito explored the place and grew shriller in indignation at Woodhouse's ointment. Then the lantern went out and all the observatory was black.

Woodhouse shifted his position presently, when the slow movement of the telescope had carried it beyond the limits of his comfort.

He was watching a little group of stars in the Milky Way, in one of which his chief had seen or fancied a remarkable colour variability. It was not a part of the regular work for which the establishment existed, and for that reason perhaps Woodhouse was deeply interested. He must have forgotten things terrestrial; all his attention was concentrated upon the great blue circle of the telescope-field—a circle powdered, so it seemed, with an innumerable multitude of stars, and all luminous against the blackness of its setting. As he watched he seemed to himself to become incorporeal, as if he too were floating in the ether of space. Infinitely remote was the little faint red orb he was observing.

Suddenly the stars were blotted out. A flash of blackness passed, and they were visible again.

"Queer," said Woodhouse. "Must have been a bird."

The thing happened again, and immediately after the great tube shivered as though it had been struck. Then the dome of the observatory resounded with a series of thundering blows. The stars seemed to sweep aside as the telescope swung round and away from the slit in the roof.

"Great Scott!" cried Woodhouse. "What's this?"

Some huge vague black shape, with a flapping something like a wing, seemed to be struggling in the aperture of the roof. In another moment the slit was clear again, and the luminous haze of the Milky Way shone warm and bright.

The interior of the roof was perfectly black, and only a scraping sound marked the whereabouts of the unknown creature.

Woodhouse had scrambled from the seat to his feet. He was trembling violently and in a perspiration with the suddenness of the occurrence. Was the thing, whatever it was, inside or out? It was big, whatever else it might be. Something shot across the skylight, and the telescope swayed. He started violently and put his arm up. It was in the observatory, then, with him. It was clinging to the roof, apparently. What the devil was it? Could it see him?

He stood for perhaps a minute in a state of stupefaction. The beast, whatever it was, clawed at the interior of the dome, and then something flapped almost into his face, and he saw the momentary gleam of starlight on a skin like oiled leather. His water-bottle was knocked off his little table with a smash.

The sense of some strange bird-creature hovering a few yards from his face in the darkness was indescribably unpleasant to Woodhouse. As his thought returned he concluded that it must be some night-bird or large bat. At any risk he would see what it was, and pulling a match from his pocket, he tried to strike it on the telescope seat. There was a smoking streak of phosphorescent light, the match flared for a moment, and he saw a vast wing sweeping towards him, a gleam of grey-brown fur, and then he was struck in the face and the match knocked out of his hand. The blow was aimed at his temple, and a claw tore sideways down to his cheek. He reeled and fell, and he heard the extinguished lantern smash. Another blow followed as he fell. He was partly stunned, he felt his own warm blood stream out upon his face.

Instinctively he felt his eyes had been struck at, and, turning over on his face to protect them, tried to crawl under the protection of the telescope.

He was struck again upon the back, and he heard his jacket rip, and then the thing hit the roof of the observatory. He edged as far as he could between the wooden seat and the eyepiece of the instrument, and turned his body round so that it was chiefly his feet that were exposed. With these he could at least kick. He was still in a mystified state. The strange beast banged about in the darkness, and presently clung to the telescope, making it sway and the gear rattle. Once it flapped near him, and he kicked out madly and felt a soft body with his feet. He was horribly scared now. It must be a big thing to sway the telescope like that. He saw for a moment the outline of a head black against the starlight, with sharply-pointed upstanding ears and a crest between them. It seemed to him to be as big as a mastiff's. Then he began to bawl out as loudly as he could for help.

At that the thing came down upon him again. As it did so his hand touched something beside him on the floor. He kicked out, and the next moment his ankle was gripped and held by a row of keen teeth. He yelled again, and tried to free his leg by kicking with the other. Then he realized he had the broken water-bottle at his hand, and, snatching it, he struggled into a sitting posture, and feeling in the darkness towards his foot, gripped a velvety ear, like the ear of a big cat. He had seized the water-bottle by its neck and brought it down with a shivering crash upon the head of the strange beast. He repeated the blow, and then stabbed and jobbed with the jagged end of it, in the darkness, where he judged the face might be.

The small teeth relaxed their hold, and at once Woodhouse pulled his leg free and kicked hard. He felt the sickening feel of fur and bone giving under his boot. There was a tearing bite at his arm, and he struck over it at the face, as he judged, and hit damp fur.

There was a pause; and then he heard the sound of claws and the dragging of a heavy body away from him over the observatory floor. Then there was silence, broken only by his own sobbing breathing, and a sound like licking. Everything was black except the parallelogram of the blue skylight with the luminous dust of stars, against which the end of the telescope now appeared in silhouette. He waited, as it seemed, an interminable time.

Was the thing coming on again? He felt in his trouser-pocket for some matches, and found one remaining. He tried to strike this, but the floor was wet, and it spat and went out. He cursed. He could not see where the door was situated. In his struggle he had quite lost his bearings. The strange beast, disturbed by the splutter of the match, began to move again. "Time!" called Woodhouse, with a sudden gleam of mirth; but the thing was not coming at him again. He must have hurt it, he thought, with the broken bottle. He felt a dull pain in his ankle. Probably he was bleeding there. He wondered if it would support him if he tried to stand up. The night outside was very still. There was no sound of anyone moving. The sleepy fools had not heard those wings battering upon the dome, nor his shouts. It was no good wasting strength in shouting. The monster flapped its wings and startled him into a defensive attitude. He hit his elbow against the seat, and it fell over with a crash. He cursed this, and then he cursed the darkness.

Suddenly the oblong patch of starlight seemed to sway to and fro. Was he going to faint? It would never do to faint. He clenched his fists and set his teeth to hold himself together. Where had the door got to? It occurred to him he could get his bearings by the stars visible through the skylight. The patch of stars he saw was in Sagittarius and south-eastward; the door was north—or was it north by west? He tried to think. If he could get the door open he might retreat. It might be the thing was wounded. The suspense was beastly. "Look here!" he said, "if you don't come on, I shall come at you."

Then the thing began clambering up the side of the observatory, and he saw its black outline gradually blot out the skylight. Was it in retreat? He forgot about the door, and watched as the dome shifted and creaked. Somehow he did not feel very frightened or excited now. He felt a curious sinking sensation inside him. The sharply-defined patch of light, with the black form moving across it, seemed to be growing smaller and smaller. That was curious. He began to feel very thirsty, and yet he did not feel inclined to get anything to drink. He seemed to be sliding down a long funnel.

He felt a burning sensation in his throat, and then he perceived it was broad daylight, and that one of the Dyak servants was looking at him with a curious expression. Then there was the top of Thaddy's face upside down. Funny fellow, Thaddy, to go about like that! Then he grasped the situation better, and perceived that his head was on Thaddy's knee, and Thaddy was giving him brandy. And then he saw the eyepiece of the telescope with a lot of red smears on it. He began to remember.

"You've made this observatory in a pretty mess," said Thaddy.

The Dyak boy was beating up an egg in brandy. Woodhouse took this and sat up. He felt a sharp twinge of pain. His ankle was tied up, so were his arm and the side of his face. The smashed glass, red-stained, lay about the floor, the telescope seat was overturned, and by the opposite wall was a dark pool. The door was open, and he saw the grey summit of the mountain against a brilliant background of blue sky.

"Pah!" said Woodhouse. "Who's been killing calves here? Take me out of it."

Then he remembered the Thing, and the fight he had had with it.

"What *was* it?" he said to Thaddy—"the Thing I fought with?"

"*You* know that best," said Thaddy. "But, anyhow, don't worry yourself now about it. Have some more to drink."

Thaddy, however, was curious enough, and it was a hard struggle between duty and inclination to keep Woodhouse quiet until he was decently put away in bed, and had slept upon the copious dose of meat-extract Thaddy considered advisable. They then talked it over together.

"It was," said Woodhouse, "more like a big bat than anything else in the world. It had sharp short ears and soft fur, and its wings were leathery. Its teeth were little, but devilish sharp, and its jaw could not have been very strong or else it would have bitten through my ankle."

"It has pretty nearly," said Thaddy.

"It seemed to me to hit out with its claws pretty freely. That is about as much as I know about the beast. Our conversation was intimate, so to speak, and yet not confidential."

"The Dyak chaps talk about a Big Colugo, a Klang-utang—whatever that may be. It does not often attack man, but I suppose you made it nervous. They say there is a Big Colugo and a Little Colugo, and a something else that sounds like gobble. They all fly about at night. For my own part I know there are flying foxes and flying lemurs about here, but they are none of them very big beasts."

"There are more things in heaven and earth," said Woodhouse—and Thaddy groaned at the quotation—"and more particularly in the forests of Borneo, than are dreamt of in our philosophies. On the whole, if the Borneo fauna is going to disgorge any more of its novelties upon me, I should prefer that it did so when I was not occupied in the observatory at night and alone."

H. G. Wells.

Selenographical Notes.

Apianus and Playfair.—These prominent ring-plains, though of moderate dimensions when compared with many of the giant enclosures in the neighbourhood, are well worthy of examination under almost every phase of oblique illumination, but especially so when the morning terminator lies about 5° east of the first, or when it intersects Aliacensis. The broad east wall of Apianus, rising more than 9000 feet above the smooth dark-grey floor, exhibits some fine terraces and several minor depressions not shown in the maps. The rampart on the west is broken by four large craters, the largest of which stands on its crest and casts a fine spire of shadow across the interior under a low morning Sun. Two others north of this occupy a place where the wall sinks down to at least one-half of its average height. Schmidt shows four small craters on the floor, one of which, a little east of the centre, I glimpsed at 8^h, March 24, 1893, but have never succeeded in seeing any other features. The border appears to be tolerably continuous except on the north, where it is interrupted by a narrow valley which, curving slightly towards the west, runs up to the southern flank of Playfair. This valley is bounded on the west by a lofty mountain-range (marked *a* in Neison's map), includes a peak apparently as lofty as any of those on the wall of Apianus, and is crowned at one point by a brilliant little crater. A little west of the valley which intersects the northern border of Apianus is a low ring about 8 or 9 miles in diameter abutting on its outer slope, noteworthy from the fact that it is partially encircled by a second low wall concentric with it.

East of Apianus, and closely associated with it, is a prominent but somewhat smaller enclosure, which Schmidt has named "Krusenstern"; and north of this, and flanked on the west by Playfair, is a remarkably fine formation, at least three times as large as Apianus, to which no distinctive name has been given, though from its size, the massiveness of its rampart, and its conspicuous details, it unquestionably deserves one. At the phase referred to above, when the shadows of the peaks on the east wall of Playfair and those on the mountain-arm extending from the latter formation to Apianus fall on its smooth slaty-blue interior, its individuality is as marked as that of Aliacensis, Werner, and other great ring-mountains in the vicinity.

Playfair, which at sunrise appears to be little more than a large crater on the rim of this noteworthy circumvallation, is a smaller and more regular formation than Apianus; its walls rise to almost the same altitude, and are clearly terraced internally on the west. The outer slope on this side falls with a very gentle gradient to the surrounding plain, and exhibits no detail. On the north there is a bright little crater, the only conspicuous object of the kind on the border. Like Apianus, Playfair has no central mountain. Of the four solitary craters shown by Schmidt on the floor I have seen but one, viz. that on the north of the centre.

CASSINI.—Among many other interesting and important observations which I have received from M. Leo Brenner, of the Manora Observatory, is one relating to the discovery of three hills between the large craters Cassini A and B, and a probable cleft in the north-western wall terminating on the edge of the floor at another little hill. Observers have long been aware of the existence of something, whether hill or crater was doubtful, about midway between A and B, but no one, so far as I know, has succeeded in detecting the three little objects shown in M. Brenner's sketch. The other details are also unrecorded.

Beaumont House, Shakespeare Road,
Bedford, 1894, Sept. 19.

T. GWYN ELGER.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The Periodicity of the Solar Spots.

Gentlemen,—

In the number of the 'Observatory' for August 1893 (vol. xvi. p. 294) you inserted a letter from me on the "Periodicity of the Solar Spots and its cause." Respecting this letter M. Flammarion did me the honour to say ('L'Astronomie,' vol. xii. p. 405) that it "est particulièrement digne de notre attention." He gives a translation of it, and then remarks that my theory "est ingénieuse, mais elle éveille plus d'une objection." Of the justice of the latter part of this remark I am well aware, but objections are not necessarily insuperable, and I am satisfied if my letter "appelle de nouveau la discussion." My attention has been recalled to the subject by an interesting article by Mr. Maunder in the August number of 'Knowledge'—"On a prolonged Sun-spot Minimum"—in which he points out the great probability that from the year 1655 to 1705 "the ordinary progress of the solar cycle appears to have been in abeyance, and we can hardly speak of it but as an extraordinary and immensely prolonged minimum." But perhaps, although occasionally spots and groups of spots were seen before, the periodicity did not commence until the beginning of the eighteenth century. Perhaps the meteoric stream, which in my view was the cause of the subsequent periodicity, may have been introduced about that time into the solar system by the attraction of Saturn, as the Leonid swarm probably was, according to the suggestion of Le Verrier, by the attraction of Uranus in the second century of our era. My theory is only put forth in the rough, and it may take a considerable time to determine whether its details can be made to correspond with observed facts; but it still seems to be the most probable theory of the cause of the periodicity which has been one of the discoveries of the present century. But if it be true, there was not much force in Johnson's remark that Schwabe had detected what had eluded even the suspicion of astronomers for 200 years. Of course, if it should ultimately prove to be correct, as the meteoric stream will probably become by degrees more generally diffused along its orbit, so as at last to resemble the Perseid rather than the Leonid shower, the varying frequency and number of the solar spots will also, as time goes on, become less marked until the periodicity ceases.

Yours faithfully,

Blackheath, 1894, Sept. 3. W. T. Lynn.

P.S.—It has been objected to the above theory that irregularities in the dates of maxima and minima of solar spots have occurred on several occasions (see Dr. Rudolf Wolf's paper in Vol. xliii. of the 'Memoirs' of the R. A. S.) even in the present century. But the meteoric ring is not suggested as the producing cause of all the spots; and if an unusual number of others occurred near an epoch of minimum, this would obscure its date, whilst, on the other hand, a large number of sporadic spots near an epoch of maximum would protract that maximum, and might appear to disturb its proper date.—W. T. L.

The first observed Transit of Mercury.

GENTLEMEN,—

Next month Mercury will again pass over the Sun's disk; and Prof. Turner has taken the opportunity of pointing out the superior position which our western cousins will occupy for its observation, the whole of the phenomenon being visible (weather permitting) on the American continent, whereas here it can be seen only at ingress and for a short time afterwards, the Sun setting at Greenwich about 19 minutes after commencement.

Perhaps a few words may be of interest with regard to the first occasion on which a phenomenon of this kind was seen. It is well known that the transit of November 7, 1631, had been predicted by Kepler, who died very nearly a year before it took place. The only person who is known to have observed it was Gassend, who did not see it directly, but on an image of the Sun projected upon a sheet of white paper in a dark chamber, in the way in which Scheiner, and our persevering contemporary, Mr. Howlett, observed the spots on the Sun. But it is probably not so generally known that an attempt (frustrated by clouds) was made to observe it by Martin Hortensius (whose real name was Van den Hove), Professor of Mathematics at Amsterdam, whilst Gassend was observing it at Paris. On hearing of the success of his friend, his delight, he tells us, was extreme. Gassend sent him a copy of his treatise, 'Mercurius in sole visus Venus invisa'; for transits of both planets took place that year, but that of Venus was not visible in this part of the world. Hortensius published in 1633 a 'Dissertatio de Mercurio in sole viso et Venere invisa,' with a dedication to Gassend, in which he describes his feelings at the reception of the account given by the latter in his treatise. "O quanto affectu scriptum hoc accepi! Quàm percussa mihi mens, et interiores isti animi æstus e sedibus suis moti! Quàm crebra in ore meo hæc vox: Felicem GASSENDUM, qui quod votis tam crebris expetierant Astronomi, vidit, obtinuit, et quod amplius, in lucem dedit, non suppressit! Felicem me, cui quod nubes invidere, ab eo nancisci datum est, cui nec scientia defuit, nec industria in observando!" Hortensius had no other opportunity of looking for a transit of Mercury, as he died in 1639, at the early age of 34, a few months before the transit of Venus which was observed in Lancashire by Horrox and Crabtree.

Yours faithfully,

Blackheath, 1894, Sept. 15. W. T. LYNN.

Bright Projections on Mars.

GENTLEMEN,—

A good deal of discussion appears to have taken place recently in various journals on the question of bright projections on Mars, and the observations of M. Perrotin and the Lick observers have been treated as announcing a new discovery. I do not think there is anything novel in these observations.

Your article in the current number of the 'Observatory' is, however, in error in one point. You say "the *first* hint of such bright markings came from Prof. Schiaparelli, who, in 1888, in publishing some observations of white spots stated that the whiteness was always more pronounced when the spots were near the edge of the disk, but he did not observe the brightness *beyond* the terminator."

If you will be kind enough to refer to the 'Monthly Notices' for June 1873 (vol. xxxiii. p. 476), you will see that I have described and delineated a white spot on the terminator of Mars "glistening as bright as the polar ice," and that "I thought the spot brighter on the terminator than when near the centre of the disk." In one sketch I showed this bright spot "apparently raised above the disk by irradiation." This spot was observed on several occasions.

I believe these are the earliest observations of this particular phenomenon.

It should be noted that, in the corresponding phase of the planet in 1884, I could detect no bright spot in the same areographical position.

Yours faithfully,

EDWARD B. KNOBEL.

3 Tavistock Square, W.C.,
1894, Sept. 22.

Fireball on August 20.

GENTLEMEN,—

It is to be hoped some of your readers noticed the fireball on Monday evening, August 20. It was witnessed here by myself and two others. Time 8.35¼. Apparent diameter half the size of the Moon. Bluish. Started midway between ζ Aquilæ and α Ophiuchi, vanishing about 4° east of 70 Ophiuchi. Duration short, not above 2 seconds.

Faithfully yours,

S. J. JOHNSON.

Melplash Vicarage, Bridport,
1894, Sept. 13.

Visibility of Jupiter's Satellites.

GENTLEMEN,—

The instances of the visibility of the satellites of Jupiter without instrumental assistance are so few that it seems worth while to note an error on this point in the recent edition of Webb's 'Celestial Objects,' i. p. 175. It is stated "two are said to have been recently perceived by several persons at Devizes . . . . [H. C.] Levander saw I., 1859." These are really one and the same observation, not of I., but of III. and IV., as afterwards verified. The error is only partially corrected in vol. ii. p. 266. The original record occurs in a letter to the 'Times,' dated April 25, 1859.

Yours faithfully,
F. W. LEVANDER.

University College School,
Gower Street, W.C.,
1894, Sept. 15.

OBSERVATORIES.

[Continued from p. 306.]

GÖTTINGEN. *W. Schur.*—By measuring the distances between several stars lying nearly in a straight line, Dr. Schur has determined the systematic errors of his instrument, and has applied them to completely reduce his last year's observations for the triangulation of Præsepe. He has also continued the triangulation of the star-clusters in Perseus, has measured Jupiter's diameter on two evenings, and has discussed the motion and parallax of the double star 70 Ophiuchi. Dr. Ambronn has continued his triangulation of stars near the Pole. He has discussed his measures of the diameter of Venus in the Ast. Nach., No. 134, and has continued his observations of wide doubles for comparison with OΣ. He has also observed Moesting A and some star-spectra. Besides these, observations of γ Draconis, Polaris, Moesting A, planets, and comparison stars of comets have been made by him and his assistant, Dr. Grossman, with the meridian-circle. Professors Albrecht and Borrass, from Potsdam, have been determining the longitudes with Bonn and Ubagsberg. Dr. Schur has also undertaken a new reduction of Olbers' Comet observations.

HAMBURG. *G. Rümker.*—Observations were made on 188 nights with the meridian-circle and on 74 nights with the equatorial. The meridian-circle observations consisted of time-determinations, Moon culminators, comparison-stars, and some of the brighter minor planets. The equatorial was out of use from Aug. 11 to Oct. 9, owing to repairs of the dome. 90 observations of minor planets were made. Comet Holmes 1892 III. was observed on 9 nights, Brooks 1893 I. on 11 nights, Rordame-Quénisset 1893 II. on 9 nights, Brooks 1893 IV. on 10 nights. The time-signals, testing and repairs of chronometers for the German Navy were carried on as usual. On April 1, 1893, Mid-European Time was adopted instead of Hamburg Time.

HERÉNY. *E. v. Gothard.*—An objective prism has been mounted for photo-spectroscopic work, with which experimental work has been done. Photographs of the following nebulæ have been obtained with the 10½-in. reflector. Gen. Cat. 1127 (2¼ hrs.), 1861–63 (3 hrs.), 2373–7 (3 hrs.), 2024 (2 hrs.), 4600 (3 hrs.). Meteorology.

JENA (University Observatory). *O. Knopf.*—A small new universal instrument has been acquired for the use of students. Comet Holmes 1892 III. was observed on 4 nights, Brooks 1893 I. on 2 nights, and Rordame-Quénisset 1893 II. on 2 nights. 90 observations of minor planets were also made. Time-service. Meteorology.

JENA. *W. Winkler.*—Herr Winkler has found it necessary to remove his observatory from Leipzig to Jena, owing to the disturbing influence of a neighbouring music-hall. In continuation of his former work he has made observations of sun-spots on 236 days, has made time-determinations on 38 evenings, has observed Comet Rordame-Quénisset on 3 evenings, and phenomena of Jupiter's satellites when possible.

KALOCSA. *J. Fényi.*—Drawings showing the position and magnitude of sun-spots have been made on 165 days. The Sun's limb was completely examined for protuberances on 140 days and partially on 150 days. Two immense protuberances were seen on Sept. 19 and 20, the latter of which was 11′ 30″·6 above the Sun's limb. Meteorology,

KARLSRUHE. *W. Valentiner.*—6250 meridian observations have been made, including 100 observations of the Moon's limbs and 50 of Moesting A, 9 of Saturn, 6 of Hebe, and about 4000 stars between 0° and 8° S. decl. With the 6-inch refractor 2 observations were made of Comet Holmes 1862 III., 7 of Brooks 1893 I., 1 of Rordame-Quénisset 1893 II., 11 of Brooks 1893 IV., and 34 of minor planets. A large number of groups of pairs of stars were made with the Bamberg transit-instrument. A good deal of time was occupied in providing time-determinations for Dr. Haid, who was making pendulum observations in the Schwarzwald. Meteorology. It is proposed to remove this observatory to Heidelberg, where a site has been granted on the Gaisberg for this and for Dr. Wolf's astrophysical work.

KIEL. *A. Krueger.*—"Die Centralstelle für astronomische Telegramme." Prof. Lamp has made observations in the prime-vertical for the determination of variation of latitude. In the spring a catalogue of the coloured stars between the pole and −23° decl. appeared, and since then a publication on the determination of the paths of comets &c., by Herr Kreutz, Lamp, and Krueger.

KÖNIGSBERG. *C. F. W. Peters.*—Observations of stars between 83° and 84° N. decl. down to the 9th magnitude. 8 observations of Comet Brooks 1892, 4 of Holmes, 6 of Quénisset, and 5 of Brooks 1893, were made. Dr. Franz has been engaged in measuring photographs of the Moon taken at the Lick Observatory, and has been considering especially the ellipticity of the Moon's form in the direction of the Earth. The meteorological observations since 1848 have been reduced by Dr. Cohn.

LEIPZIG. *H. Bruns.*—Dr. Peter continued his measures of parallax with the heliometer. Dr. Hayn has observed 200 double stars and about 400 other stars in the Zone 10°–15° N. decl., and has begun similar work for the Zone 5°–10°. Dr. Hartmann has been measuring the position of the shadow in photographs of the lunar eclipse of 1889 Jan. 16. Determination of latitude with a universal instrument by Drs. Schumann, Hayn, and Hartmann. Time-service. Meteorology.

LUND. *A. Möller.*—4759 zone stars were observed.

MILAN. *G. Schiaparelli.*—Measures of 567 double stars have been made with the 18-in. refractor. Prof. Celoria has made 103 measures with the 8-inch. In connection with the Geodetic survey of Italy the difference of longitude of Parma and Milan was found to be $4^{m}\ 32^{s}{\cdot}902 \pm {}^{s}{\cdot}013$. Magnetic and meteorological observations. Time-service.

[To be continued.]

ROYAL OBSERVATORY, CAPE OF GOOD HOPE.—Dr. Gill has supplemented his Report for the ten years 1879–89, noticed in our number of August last, by two reports, one for the years 1889–92, the other for the year 1893, thus bringing this publication, which will in future be annual, up to date. It is a little disquieting to learn from these that from the end of 1891, owing to the inadequacy of the computing staff,—which is not able to cope with the amount of work required to bring up arrears of reduction and at the same time to reduce current Meridian and Heliometer observations,—"Meridian observing not absolutely required for immediate use was given up and every effort made to overtake the arrears of computation and publication." The average annual number of observations with the transit-circle during the years 1889–91 were: Transits 5972, Zenith-distances 5155; and the similar average numbers for the period 1892–3, 1019 and 452.

The zenith telescope was used in the years 1889–90 for observations of stars by Talcott's method, for the purpose of comparing northern and southern systems of declination, and in 1892 and 1893 for determining the constant of aberration and detecting change of latitude. The whole number of observations made with this instrument in the four years was 4222. Extensive alterations were made in this instrument in the year 1891, which have considerably improved its performance. The first Report refers to the work done with the heliometer in connection with Dr. Gill's investigation of the value of the Solar Parallax, the result of which he gave in his communication to the 'Monthly Notices' of April last. The observations for this work were completed in 1890; since then the instrument has been used for observations of various kinds, principally for determinations of stellar parallax. No observations were made in 1893. The Astrographic Equatoreal was received on 1890, June 11, and after several alterations and some experimental work, the regular work on the chart was begun on

1892, July 26; since that date 1474 successful plates have been taken with the instrument.

During the five years 122 occultations of stars by the Moon have been observed, and various comets have been observed on 77 nights in all.

Mr. G. W. H. Maclear retired after 41 years' service on 1893, June 30. The vacancy thereby caused in the rank of Second Class Assistants has been filled by the promotion of Mr. W. H. Cox, formerly Junior Assistant: we understand that this last-mentioned post will be filled up shortly.

NOTES.

COMET NOTES.—M. Schulhof has determined new elements of Tempel's second periodic comet, with the aid of this year's observations, as follows:—

Epoch 1894 June 4·0 Paris M.T.

M......	$7^\circ\ 53'\ 9''\cdot5$	
π	$306\ \ 15\ \ 0\cdot3$	1894·0.
☊......	$121\ \ 10\ \ 5\cdot5$	
i	$12\ \ 44\ \ 21\cdot9$	
ϕ	$33\ \ 26\ \ 27\cdot4$	
μ	$679''\cdot9371$	
log a....	0·478358	

He gives the following ephemeris for Paris midnight:—

Oct. 4, R.A. $4^h\ 2^m\ 1^s$, S. Decl. $0^\circ\ 6'$; Oct. 8, R.A. $3^h\ 59^m\ 46^s$, S. Decl. $0^\circ\ 31'$; Oct. 12, R.A. $3^h\ 56^m\ 59^s$, S. Decl. $0^\circ\ 55'$.

Dr. Hind has published the following improved elements of Denning's Comet:—

T=1894 Feb. 9·62424 G.M.T.

π	$130^\circ\ 44'\ 55''\cdot2$	
☊......	$84\ \ 4\ \ 40\cdot9$	1894·0.
i	$5\ \ 33\ \ 19\cdot2$	
ϕ	$44\ \ 50\ \ 40\cdot7$	
μ	$460''\cdot9345$	
log a....	0·5909116	
Period ..	7·698 years	

In Ast. Nach. 3249 there is an article by Herr Thraen on Comet 1886 II., for which a hyperbolic orbit was found. He concludes that this can be explained by planetary perturbations, and that on 1882 Oct. 5 the comet was moving in a parabola and earlier still in an ellipse.

Dr. Backlund has published two further memoirs on Encke's Comet, which contain an analysis of the perturbations produced by Venus, the Earth, Mars, Jupiter, and Saturn from 1819 to 1848, and by Mercury from 1819 to 1891. This comet will pass perihelion about Feb. 6 next, and will probably be visible in two or three months.

A. C. D. C.

THE ATMOSPHERE OF MARS *.—Prof. W. W. Campbell, of the Lick Observatory, has re-opened the question of the existence of an atmosphere on Mars, and of its constituents if it exists. Let us first consider the conditions and the data necessary for the solution of this problem before proceeding to Prof. Campbell's observations. The light that reaches our eye from Mars, emanating from the Sun, passes first through the solar envelope, then through Mars' atmosphere, if there be such, and after reflection from the surface of the planet, returns through the same and finally traverses the Earth's own atmosphere to reach our eye or telescope. Hence, when the spectroscope is applied to analyse this light, if Mars has an atmosphere like our own, it should show the spectrum characteristic of the Sun, affected by the absorption of Mars' atmosphere, which would weaken the continuous spectrum and add many dark lines, and lastly our atmosphere would affect the spectrum in the same manner. It would seem at first sight that, as the last two effects are the same, the problem is impossible of solution. The difficulty is to some extent superseded by introducing our Moon as a factor.

Assuming that the Moon has no atmosphere, if the spectrum of its light be examined it would show the solar spectrum with the lines due to our atmosphere added; hence if when the spectrum of the light from Mars be compared with the lunar spectrum, and additional lines be seen, or if there be any difference in appearance of the lines, there is a fair inference that these differences are due to Mars. For example, if Mars has an aqueous atmosphere like our own, we should expect to find the dark lines due to the presence of water in our atmosphere better defined in the Martian than in the lunar spectrum.

The problem of the Martian atmosphere has been attacked before by eminent spectroscopists, Huggins, Vogel, Janssen, Secchi, who have all satisfied themselves of the existence of aqueous vapour, and now Prof. Campbell, feeling that improvements in spectroscopic apparatus, a telescope of great focal length, the altitude of the Lick Observatory, which at once eliminates the effect of 4200 feet of terrestrial atmosphere, and its latitude, which enables Mars to be observed at some altitude, are circumstances which would conspire to give him a result worthy of confidence, has again attempted its solution.

The parts of the spectrum chosen for observation were the groups of lines about the regions Hα and D, which indicate the presence of watery vapour in the atmosphere. Other similar lines were rejected because their proximity to metallic lines rendered them difficult of observation; but those selected were observed in the spectra of both Mars and the Moon on ten nights between June 29 and August 10 of the present year. The utmost care was taken that both bodies should be observed under similar conditions, and especially that both bodies should be at the same altitude, and the observations were made under varying conditions of

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* 'Publications of the Astronomical Society of the Pacific,' Vol. vi. No. 37.

humidity of the atmosphere. Prof. Campbell found that the spectrum of Mars was always the same as that of the Moon in every respect. As would be expected, the atmospheric and vapour lines were seen to decrease in intensity as the altitude of the objects increased, and the vapour lines varied in intensity with the amount of vapour in our atmosphere. Further, the spectrum of light from the limb of Mars was compared with that of light emanating from the centre of the disk; as the light, in the first case, would pass through a greater thickness of the Martian envelope, a corresponding difference in the spectra might be expected. This was not found to be the case.

It must be noticed that these observations do not prove the absolute non-existence of a Martian atmosphere. The next question which presents itself is, How dense or what extent of atmosphere would be required to produce an appreciable effect on the telluric spectrum? In the course of this work it was noticed that the aqueous lines were appreciably more intense when the bodies were at an altitude of 30° than when they were at 55°. The lengths of the paths traversed in our atmosphere corresponding to these altitudes are in the ratio 2 : 1·22. Prof. Campbell thinks that an increase of 25 per cent. in the length of atmosphere traversed would cause a quite perceptible difference in the intensity of the lines; and if so, a Martian atmosphere one fourth as extensive as our own ought to have been detected by this method.

THE MASS OF JUPITER.—Prof. Simon Newcomb, we learn from Ast. Nach. No. 3249, has brought to a close his investigations of the orbit of Polyhymnia which he has carried on at intervals, as opportunity offered, during the last ten years. The main purpose of the work was to determine the mass of Jupiter by the investigation of the perturbations of the small planet; and so far as this purpose is concerned the work is complete, but Prof. Newcomb suggests that in the interests of future astronomy it would be well to observe Polyhymnia with other small planets continuously by Dr. Gill's heliometer method and to continue the work on the perturbations which he has begun.

If the mass of Jupiter be $\frac{1}{\mu}$ of the Sun's mass, the values of μ found by Prof. Newcomb's and by other methods are as follows:—

		Wt.
All observations on the satellites	μ=1047·82	1
Action on Faye's comet (Möller)	1047·79	1
Action on Themis (Krueger)	1047·54	5
Action on Saturn (Hill)	1047·38	7
Action on Polyhymnia (Newcomb)	1047·34	20
Action on Winnecke's comet (Haerdtl)....	1047·17	10
Weighted mean	1047·35	

RECENT LARGE SUN-SPOTS AND MAGNETIC DISTURBANCES.—A large group of spots was visible on the Sun in August, accompanied, as is not unusual, by terrestrial magnetic disturbances of some violence. The group, which remained of a comparatively compact shape through its period of visibility, August 11 to August 22, was not of extreme size, its area covering about 2000 millionths of the Sun's surface. The magnetic storm was of short duration, beginning about 3 A.M. on August 20 (three days after the spot had passed the central meridian) and ending about 3 P.M. on the same day, but of great activity, the maximum periods occurring between 5^h and 6^h 30^m A.M. and from 8^h 30^m to 10^h A.M.

Another magnetic storm of feebler dimensions occurred on Sept. 14–15. The sudden kick of the recording-needles which always heralds this phenomenon occurred about 1 o'clock in the early morning of Sept. 14, and activity prevailed in both elements until the evening, when it was especially pronounced between 11 P.M. and 1 hour after midnight: the storm subsided at 5 o'clock on the morning of the 15th. Cloudy weather on these days prevented observation of the Sun, but, from the record of previous days, it appears that there was a spot of moderate dimensions, perhaps 1000 millionths, on the hemisphere of the Sun turned towards us.

THE SUMMER OF 1894.—As contrasted with the long and brilliant summer of 1893, the cold wet summer of the present year stands out very unfavourably. In 1893 there were 29 days on which the temperature rose above 80°, whilst in 1894 there were only 7 such days. The hottest day in 1894 was the 6th of July, when a maximum temperature of 86° was recorded, the mean temperature for the day (70°·7) being in excess of the corresponding average by 8°·5. On the hottest day in 1893—the 18th of August—the temperature reached 95°, and the daily mean (79°·6) was no less than 18° above the corresponding average temperature. On three consecutive days in May of the present year (May 20 to 22) the remarkably low mean temperature of 43°·0 was obtained, being 11°·6 below the 50 years' average, and a similar instance of three consecutive days of low temperature occurring so late in the year is only to be found in 1867 (May 22 to 24), when the mean was as low as 41°·3.

The mean temperature for the six months April to September 1894 was 0°·8 below the average for the 50 years 1841–1890, whilst in 1893 it was 2°·6 in excess of the average. The number of hours of bright sunshine recorded from the vernal to the autumnal equinox, embracing the period during which the Sun was north of the equator, amounted to 1157 in 1893, and in the corresponding period in 1894 to 762. In 1893 there were only 10 sunless days during this period, but in the present year there were 25. As relating to this subject it may be interesting to note that the mean percentage of cloudiness from April to September in 1893 was 51, whilst in 1894 it amounted to 67. The average amount of cloud for these months, as derived from observations made during a period of 70 years, is 64 per cent. During the six months rain fell on 63 days in 1893 to the amount of 7·34 inches, being 5·42 inches *below* the average amount. In 1894 it fell on 96 days to the amount of 12·54 inches, which is very nearly the same as the average amount. This, as do all the above figures, refers to the locality of Greenwich. W. C. N.

A remarkable Meteor.—Accounts are to hand from Wales, the Midlands, and the South of England of a magnificent meteor seen on the evening of Sunday, August 26, which was remarkable for the length of duration of its streak. Most of the observers agree that it was first seen about $10^{h}\ 20^{m}$ P.M., and their reports have enabled its position at first appearance to be located at a point about 90 miles above the River Mersey, 20 miles west of Ormskirk, whence it travelled to a point about 30 miles above Ruthin in Denbigh. Spectators differ as to the length of time that the appearance lasted; most of them state that it lasted several minutes; but Mr. Corder, of Bridgwater, says that the streak left by the meteor did not disappear for half an hour. A description is given by Admiral Ommanney, who, writing to 'Nature,' states that being in Llanberris he saw an object, which is evidently the same meteor, in the constellation Cassiopeia, about $10^{h}\ 30^{m}$ P.M. on Aug. 26, which had a disk three times the diameter of that of Jupiter, and as it moved through the sky left a streak, comparable in shape to a flat fish, which lasted for five minutes.

A telegram from Kiel of Sept. 15 announces the discovery, by Prof. Hartwig, of Bamberg, that the star B.D. + 15°, 3311 is a variable of the Algol type. He gives the period as two days less 260 seconds.

Minima occurred on Sept. $16^{d}\cdot37$, $18^{d}\cdot37$, 20^{d} 36, $22^{d}\cdot36$, Greenwich Mean Time.

The Astronomical Society of the Pacific have awarded Comet Medals to Mr. Walter Gale, for his discovery of a comet on 1894 April 2, and to Prof. J. M. Schaerberle, for his discovery of an unexpected comet on the negatives of the eclipse of 1893 April 16.

Mr. David E. Packer announces the discovery of a nebula in R.A. $18^{h}\ 13^{m}\ 9^{s}$, South Decl. 18° 8′.

New Large Telescope for the Cape Observatory.—We understand that Mr. Frank M^{c}Clean has intimated to Dr. Gill his desire to present to the Royal Observatory at the Cape of Good Hope an equatoreally mounted telescope equipped for photographic and spectroscopic work. The photographic refractor will be of 24 inches aperture, and be provided with an object-glass prism having a refracting angle of 7½ degrees and the same aperture as the object-glass. Coupled with the photographic telescope there is to be a visual telescope of 18 inches aperture. The mounting is to be sufficiently elevated to allow a slit-spectroscope, for the determination of stellar motion in the line of sight, to be attached to the photographic telescope. Such a spectroscope will be subsequently provided, and also an observatory of light construction.

Subject to the approval of the Lords Commissioners of the Admiralty, Dr. Gill has cordially and gratefully accepted this splendid offer.

Our readers are already aware of Mr. McClean's important original work in astronomical physics, and will also remember his endowment of astronomical scholarships at Cambridge. They will recognize in the present gift the same generous spirit, the same devotion to the best interests of science, and the evident care with which he has considered the requirements of astronomy in this most noble proposal.

The southern heavens present a field comparatively unexplored in the department of astro-physics, and in the clear skies of the Cape a rich harvest of results may be confidently anticipated.

The new telescope has been for some time in progress in Sir Howard Grubb's workshops. The glass for the large prism was delivered in January last, and the glass for the lenses then awaited instructions for moulding. The definite order for the instrument was given to Sir H. Grubb on the 4th May last.

THERE will be a Transit of Mercury on November 10, the day following the first meeting of the Royal Astronomical Society. The proximity of the two events reminds one of the partial eclipse of 1891 June 6, which fell on the Greenwich Visitation Day, and was regarded as cleverly arranged for the occasion by some of those who came to see the sights at the Royal Observatory. The phenomenon of November 10 has been kind in rather a different way, for it has just managed to avoid a day on which many who might like to see it must necessarily be in London, where the chances are not good. The ingress alone will be visible in the British Isles, shortly before sunset; and the further west you go, the earlier will ingress occur. As we can no longer look forward to a Transit of Venus, a Transit of Mercury is perhaps of sufficient interest to repay a journey to the west of England or Ireland. An enthusiastic amateur has indeed suggested a visit to the States, where the whole transit can be seen, and has secured the co-operation of the "American line" of steamers (Southampton to New York) so far as to obtain from them a promise of special rates. At his request I duly communicated this fact to the daily press, though I am somewhat sceptical as to any particular result accruing.

AT the June meeting of the Royal Astronomical Society it was announced that Prof. Barnard, of the Lick Observatory, had sent a series of positives of his astronomical photographs as a present. These arrived in due course; and a very beautiful series they are, well worth a visit to Burlington House specially to see. There are altogether more than 60 glass positives (10 in. by 8 in. or

8½ in. by 6½ in.), chiefly of comets, but including one or two of stars, eclipses, &c. The most remarkable are perhaps those of Brooks's Comet, where the tail is in process of being shattered—as though by some cyclone of space. But all are worth careful study; and it is to be hoped that several, if not all, may be published by the Society in some form or other. The whole of the manual labour of taking the originals and copying them has been undertaken by Prof. Barnard personally. At the Lick Observatory manual assistance is no more plentiful than some other luxuries which we have come to regard almost as necessaries.

ANOTHER interesting present lately received by the Society is a series of experimental negatives taken by Warren de la Rue in the very early days of astronomical photography (1857–58). These, with a number of enlargements of the Moon, have been presented by Mr. Ernest de la Rue, and it is very satisfactory to have them for reference. The impressions of Jupiter, about 0·05 inch in diameter, taken with 5^s to 12^s exposure, show the belts clearly; and there are three of Saturn, with 60^s exposure, showing the ring. All these were taken in the winter 1857–58. A curious fact is that some plates labelled "Castor," and taken about the same time, show nothing at all. The star-images seem to have disappeared, for in his account of the experiments in the 'Monthly Notices' I see that Mr. De la Rue describes them at the time as being "intense." This fact has an important bearing on the necessity of measuring plates soon after they are taken; for if images are liable gradually to disappear from photographic plates (and this is of course not the only evidence of such tendency), then the results obtained from a plate will slowly change with the time, in a manner yet to be determined.

THE other day I was induced to buy an evening paper by the glaring announcement, "BANK OF ENGLAND—EXTRAORDINARY CHARGES": only to find that the "charges" were those on the half-yearly account due to the "extraordinary" circumstances of the Baring liquidation. I did, however, get for my penny the following paragraph, which may be new to others as it was to me:—

> "Apropos of the imminent disgrace and degradation of Li Hung Chang, we may revive an old epigram written upon the fate of two Chinese Astronomers who were put to death by the Emperor for getting drunk on the night when an eclipse was due—
>
> 'Here rest the bones of Ho and Hi,
> Whose fate was sad, yet risible,
> Being hang'd because they did not spy
> Th' eclipse that was invisible.
>
> 'Heigh ho! 'tis said a love of drink
> Occasion'd all their trouble;
> But this is hardly true, I think,
> For drunken folks see double.'
>
> "Li Hung Chang will at least have the satisfaction of knowing that he has failed worthily."

H. H. T.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 220. NOVEMBER. 1894.

Notes on Mars in 1894.

The Canals.—From recent accounts it appears that the canals have already been recognized by quite a number of observers. As early as June last, several of them were seen by Mr. Percival Lowell in Arizona, one, the Cerberus, being probably double. M. Antoniadi, at Juvisy, had identified as many as 39 canals up to the end of September, the Jamuna, moreover, having been seen double by this observer. A number have also been seen by the Abbé Moreux at Juvisy, and by MM. Jarson and Quénisset at Paris. Herr Leo Brenner at Lussinpiccolo, Istria, has seen the canals very sharply defined, about 30 having been identified with those on the map of Professor Schiaparelli. In England Mr. Cammell, of Wokingham, has observed a good many canals, and has also seen one, the Jamuna, clearly double. Mr. H. MacEwen, of Glasgow, has also seen some with a 5-in. refractor.

At Brighton observation has been much hindered by the cloudy weather. Nevertheless, by taking advantage of every favourable opportunity, 51 canals have been observed up to the present time. These include most of those shown in Professor Schiaparelli's latest map that could be properly observed at present, and in addition three others not marked in the map. Generally speaking there is no difficulty in certainly identifying the canals, with the exception of a few which are situated far north, and consequently are too close to the limb to be distinctly observed. The general accuracy of the map is very striking, and I have often been strongly impressed by the very thorough manner in which Professor Schiaparelli's work has been done. It is most rare to come across the trace of a canal not marked in his map, and the positions of objects are usually very reliable.

Phison.—In the 'Observatory,' No. 219, p. 320, it was stated that this canal was probably double. Observations, however, made on Oct. 7, a remarkably fine night, showed it to be only single. Parallel to it, and about midway between the canal and the coast bordering on the Kaiser Sea, a much feebler, unrecorded canal was suspected. It was probably the existence of this object that produced the impression of the Phison being double. It may be mentioned that the latter, observed with a power of 320 on a nearly perfect night, appeared as a narrow, very definite, and very dark streak. A line ruled with pen and ink would represent its appearance and would not be much too dark. The Schmidt Bay of Mr. Green's map is a beautiful little miniature of Dawes's Forked Bay, the Phison falling into one inlet and the Euphrates into the other.

Agathodæmon and Araxes.—As already mentioned in the note on p. 320 of the October No. of the 'Observatory,' these canals are intensely double. They have been seen double well on three or four nights in September. Agathodæmon was composed of two very dark lines somewhat widely separated, the intervening space being rather dull. Araxes also was very obscure, but narrower than the Agathodæmon; and as the space between the two component lines of the canal was nearly as dark as the lines themselves, the duplicity was not very obvious at first sight or on a poor night.

Chrysorrhoas.—Seen double with certainty on two or three nights in September. The canal, however, is inconspicuous compared with Agathodæmon and Araxes. It is worthy of note that these three canals constitute with the Nilokeras, too near the limb to be well observed, a direct line of communication between one of the largest and darkest seas in the southern hemisphere of Mars (Mare Sirenum) and the most considerable dark marking in the northern hemisphere (Lacus Niliacus and Mare Acidalium).

Amenthes.—In September this canal was narrow, inconspicuous, and apparently single. Observing it on Oct. 12 I was surprised at the change that had taken place. It now appeared as a very broad, very obscure, double canal. It has been seen on several nights since, and although definition has always been poor, the object is so broad and dusky as to immediately attract attention, and even when the seeing is bad it is obviously double. The change quite alters the appearance of this part of the planet.

Ganges.—This is another of the broad, conspicuous, double canals. The duplicity is so obvious as to be apparent on almost any night, however bad.

The small dark Spots or Lakes.—Several more of these curious little dark spots have been seen. Lacus Phœnicis on a good night appears as a small, nearly round, almost black spot, resembling the shadow of a satellite of Jupiter when in transit. On one night a feebler companion spot was seen just preceding it. Lacus Tithonius is a similar definite and nearly black spot, with a feebler companion following it. In a fine drawing of Mars, dated Sept. 5, Mr. Cammell shows Lacus Moeris as a minute dark spot, with Nepenthes as a narrow definite line, and so I have seen them on several nights lately. Also Lacus Tritonis as a similar spot. At the junction of the canals Amenthes (following component), Thoth, and Astapus there is also a little dark spot. The dark spot at the north end of the Ganges, known as Lacus Lunæ, has been rather perplexing. On several nights there was an evident appearance of duplicity about it, though it was impossible to say with certainty in which direction it was double. At length, however, the mystery was cleared up, the lake having been seen distinctly double on September 29 at right angles to the direction of the Hydraotes. The streak or bridge dividing the lake into two was bright yellow.

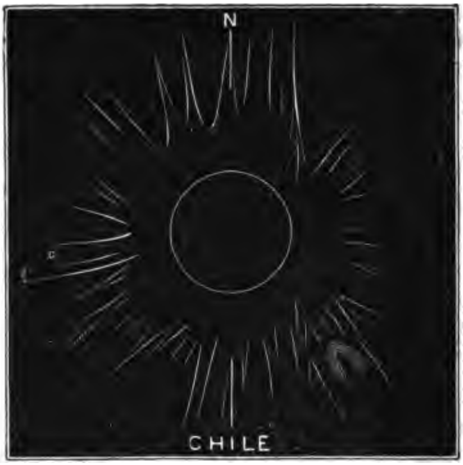
Cloud and Mist.—A great development of cloud or mist seems to have taken place lately, affecting the greater part of the extensive region lying to the north of the Mare Cimmerium. When this region was under observation in September its appearance seemed to be normal, the canals being readily observable, whilst three, Cyclops, Cerberus, and Eunostos, were conspicuous and double. The two former in particular were prominent objects, even on a bad night. On Oct. 14, when engaged in examining the region about Syrtis Minor, I was surprised at not seeing anything of either Cyclops or Cerberus, though not much attention was paid to this circumstance at the time, as they were then considerably past transit. But on the following night nothing at all could be seen of either Cyclops, Cerberus, or any of the other canals in this neighbourhood, even when they should have been in midtransit. The whole region had a monotonous yellowish-white appearance, with here and there perhaps a trace of a faint indefinite dark marking, not, however, resembling or indeed identifiable with any of the canals. This state of things continued on Oct. 16 and 17. Finally on the 19th the southernmost part of the Cyclops could be seen, but it was feeble and indistinct, and could not be traced far north.

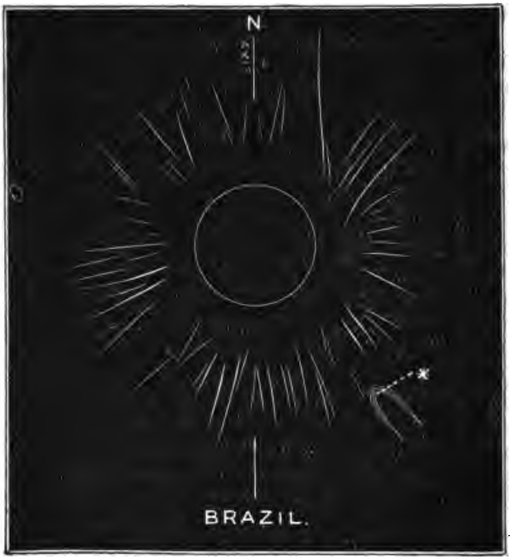
It is probable that this peculiar state of things was due to cloud, fog, or mist overlying this very extensive region. The Mare Cimmerium itself was largely affected. On Oct, 19, for instance, this sea was dark and conspicuous from the following extremity as far as the mouth of the Cyclops. But here it seemed to stop abruptly, a large yellowish-white mass apparently covering the greater part of the large area lying between this point and the Mare Sirenum, and leaving only a narrow, inconspicuous connecting channel on the south. This and some other instances which I have noticed lately lead me to think that cloud and mist formations are much more extensive and common on Mars than is generally considered to be the case.

West Brighton, 1894, Oct. 20. A. Stanley Williams.

The Comet on the Eclipse Photographs of 1893.

In 'Astronomy and Astro-Physics' for October 1893 Professor Schaeberle drew attention to a comet-like structure near the Sun, which was shown in the Chile photographs of the total eclipse of 1893, April 16. In the number of the same journal for April 1894 Mr. Schaeberle published a further note, accompanied with a sketch, in which the cometary object was shown in the south-west quadrant, apparently attached to a slender, nearly radial coronal ray near the south point of the Sun's limb. Professor Schaeberle



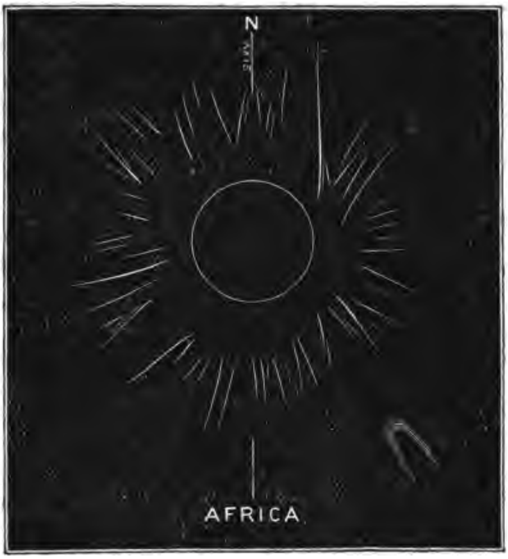


deferred expressing an opinion as to the true nature of this object, as he had not then seen copies of the photographs taken at other stations.

Subsequently I received a letter from Professor Holden, dated 1894, May 9, from which I extract the following:—

"In 'Astronomy and Astro-Physics,' 1894, April, Professor Schaeberle has drawn the Comet shown on (all) his corona negatives. The same Comet is shown (though not so well) on the positives of the British Expeditions which you have kindly sent us. The distance of the Comet from the Moon's limb in fractions of the Moon's diameter is on Lick photographs 0·88, on Brazil ± 1·15, on African ± 1·50."

Professor Holden in the same letter requested me to repeat the measures upon the original negatives taken at the Brazil and African stations.



I had previously examined the beautiful series of positives from the photographs taken by Professor Schaeberle in Chile, which had been sent to the R.A.S. from the Lick Observatory. In one of these (No. 6, 32 seconds' exposure), taken with the photoheliograph, the object was quite distinct, and fairly resembled the sketch in 'Astronomy and Astro-Physics,' though partly cut off by the edge of the plate, as mentioned by Professor Schaeberle. But none of the other positives from the Chile photographs, which were all taken with shorter exposures, showed any trace of the comet, and as it was so near the edge of the plate, which was not in that part free from photographic defects, I felt by no means certain of its reality.

Upon receiving Professor Holden's letter I examined the original negatives of the British Expeditions, both by myself and with others, but we entirely failed to identify the object shown on the single Chile photograph. Only in some of the Brazil negatives we noticed a forking of one of the coronal rays, but this did not seem sufficient to confirm Professor Schaeberle's discovery. It should be mentioned that, as the object on the Chile photograph was somewhat dense, I looked for a *dark* patch on the English negatives, and this may perhaps account for my failure to perceive it.

Under date of July 26 Professor Holden kindly wrote to me again, enclosing a copy of one of the Chile negatives, and also one made from the positive of the Brazil photograph no. 3. Marks on the plates made the exact position of the object in question quite clear, and I had no difficulty in perceiving it upon both the plates. I was prevented, however, at the time from making the detailed comparison with the English negatives, of which I now, by Prof. Turner's permission, give the results. It is evident that upon the English photographs the denser portion of the cometary object is more or less lost in the coronal rays, and I should rather have looked for the vacuity immediately outside this denser portion. This vacuity appears to be what I at first took for the space between the forks of a coronal ray.

The diagrams give approximately the position of the object, of course much intensified, upon the photographs, and the following are my measures of its distance from the Moon's limb, taking the Moon's diameter as 33′:—

Chile 29′, Brazil 36′, Africa ±47′.

The point from which the measures are taken in each case is that marked * upon the Brazil diagram. The orientation of the diagrams is very rough, especially that of the Chile photograph, as the prominences are scarcely visible upon the plate which shows the comet. It will be seen that my measures agree very fairly with those of Prof. Holden.

The measure for the Chile photograph is pretty exact; that for the Brazil nearly as good, but I am not so satisfied with the measure for the African plate. The latter was practically made from plate No. 1 only, as the object is scarcely measurable on one other, and all but invisible on the remaining negatives of this series. I think the measure upon this plate is a fairly good one, but there was some haze at the African station; the details are somewhat faint and diffused, and the presence of some photographic defects render it very difficult to be sure of the reality of so faint an object. It can be seen and measured on four of the Brazil negatives, and is just perceptible on one or two others.

I am much less certain about the direction of the axis of the comet than of its distance from the Moon's limb. On the Chile plates the axis is not directed exactly towards the Sun's centre; perhaps on the other negatives the axis may be slightly more radial in direction, but it is impossible to speak positively, and the diagram must only be considered fairly accurate as to distance from the limb.

It is unfortunate that in the English photographs taken with the enlarging-lens the plate was not sufficiently large to show the comet. It only appears (but very diffused and indefinite) on one of the Brazil negatives with the enlarged image, in which the corona was not quite in the centre of the plate. It is evident, as Professor Turner has pointed out, that for future eclipse photographs larger plates should be used than those hitherto employed. On the Brazil plates the comet would probably have been taken for a faint detail of the outer corona, and on the African photographs would have escaped observation altogether. But on the Chile negatives it is quite obvious, and the evidence of motion relatively to the Sun, given by the comparison of the plates taken at the three stations, seems to place the nature of Professor Schaeberle's interesting discovery beyond a doubt.

W. H. Wesley.

Note on the Spectrum of Mars.

Professor Campbell in his paper on the "Spectrum of Mars" (Publ. A. S. of the Pacific, vol. vi. p. 228), in speaking of the early observations of myself and others, says:—

"It is very important, as Janssen pointed out in 1867, that we eliminate as far as possible the effect of aqueous vapour in our own atmosphere. The observers do not seem to have taken this factor into account (except Janssen, the details of whose observations appear to be unpublished)."

So far is this statement from being correct that the method of eliminating the effect of our atmosphere by observations of the Moon at the same time was that originally employed by me in 1867. In speaking of faint lines seen on both sides of D, and which appeared to indicate terrestrial gases or vapours in the atmosphere of Mars, I say expressly:—"That these lines were not produced by the portion of the Earth's atmosphere through which the light of Mars had passed, was shown by the absence of similar lines in the spectrum of the Moon, which at the time of observation had a smaller altitude than Mars" (Mon. Not. R. A. S., vol. xxvii. p. 178).

In 1879 I took photographs of the spectra of Mars and other planets in the twilight, simultaneously with the spectrum of the light from the sky immediately about the planets. In these spectra no lines or modifications of the spectrum appear which are peculiar to the planet's spectrum (Trans. R. S. 1880, p. 687).

The apparatus necessarily employed by me at the early date of 1862–7 was very imperfect as compared with the instruments now in use, but I have no reason to doubt the substantial accuracy of the observations, which were made with much care.

1894, Oct. 6. WILLIAM HUGGINS.

The Rotation of Venus *.

THE rotation of Venus about its axis is one of the most delicate questions of current astronomy; it is far from being solved, some experienced observers believing that the planet constantly presents the same face to the Sun, just as the Moon does to the Earth—*i. e.* the planet rotates about its axis in the same time that it revolves in its orbit about the Sun, viz. 225 days, while other astronomers, not less experienced, are inclined to admit of a rotation of about 24 hours.

Observations of the planet are extremely difficult. Whatever may be the phase, the light is always so brilliant that very little on its surface can be distinguished. From observations made at the Observatory of Juvisy, it would appear that there are polar snow-caps similar to those on Mars, but are less evident because the general tone of Mars is a pronounced reddish-yellow, sprinkled with greyish spots, while the general tone of the disc of Venus is a bright yellow, nearly white, without very conspicuous spots.

From the series of observations made at Juvisy during the past eight years, I have selected the following, as particularly worthy of attention. Instrument used—equatorial $0^{m}\cdot24$, powers 300 and 400; observations made in daytime.

1887, *June* 11.—Diameter = $17''\cdot4$. Atmosphere perfectly transparent. The general tone of the planet is bright creamy yellow. The two extremities, north and south, of the disc marked by white spots; the inferior is just cut by the terminator, the south is a little to the left. These two spots were also well seen with the small 108 mm. finder attached to the equatorial.

1887, *June* 17.—D.=$18''\cdot2$. The two polar caps well seen, the superior being the larger.

1890, *Dec.* 14.—D.=$58''\cdot8$. Crescent very small. Towards the upper horn is noticeable a slight dazzling cushion; the horns a little beyond the semi-diameter. As usual, there is a shadow along the terminator.

1892, *April* 10.—D.=$19''\cdot2$. Sky remarkably pure. The north polar spot well marked, and appears to extend beyond the terminator. The left lower side brighter than the rest of the planet.

1892, *May* 29.—D.=$34''\cdot4$. The two polar caps visible; the south is smaller and less brilliant than the north. The south horn very narrow. Bright light towards north pole.

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* From 'Comptes Rendus,' No. 17 (Oct. 22, 1894).

1892, *June* 7.—D. = 29″·6. The south horn is very white and widened; the north is equally white but pointed.

1892, *Aug.* 23.—D. = 31″·6. The polar cap is well seen. East limb very white; south cusp narrowed.

1893, *June* 13.—D. = 9″·8. The planet's appearance recalls somewhat that of Mars. North polar spot round; south pole whitish.

1893, *Aug.* 8.—D. = 11″·2. South pole plainly visible, as has been the case during all these months. The north is uncertain. Spots on the disc.

1894, *July* 27.—D. = 12″·2. South polar spot snow-like, similar to that of Mars.

1894, *Aug.* 1.—D. = 12″·0. Both poles visible, the upper whitish, more extended, and diffused. Light spots.

If these whitened poles are not an illusion, and if they represent snow or cloud, their existence would be inexplicable in the hypothesis where the planet rotates in the same time as it revolves. In fact, in the case where it always presents the same face to the Sun, the maximum cold would be in the hemisphere opposed to the Sun, and the maximum temperature towards the centre of the illuminated hemisphere; all the circumference of the illuminated hemisphere would be in the same condition of climate.

We believe, then, to be able to deduce from observations that the planet Venus turns on its axis, and that its axis is inclined slightly to the plane of its orbit, since the two polar caps are visible at the same time. The observations of spots are insufficient to determine the duration of rotation, but they seem to indicate that it is not far from 24 hours. CAMILLE FLAMMARION.

George Knott.

WITH much regret we have to record the death of Mr. George Knott, of Knowles Lodge, Cuckfield, which took place after a short illness, from pneumonia, on the 8th of October last.

Mr. Knott, who was born October 30, 1835, and had therefore nearly completed his fifty-ninth year, was the only son of George Knott, Esq., of Bohun Lodge, East Barnet (who died in 1844), a well-known art connoisseur of his day, and the owner of a choice collection of pictures. He was educated privately, and graduated at London University, taking the B.A. degree in 1856 and LL.B. in 1857. Having lost his father when quite young, and coming early into a sufficient fortune, he married in 1859, and settled down at Cuckfield, in Sussex, where he resided until his death.

Mr. Knott's interest in astronomy was awakened by the late Dr. Drew, F.R.A.S., of Southampton, who was for a short time his tutor, and his first telescope was a 4-inch Gregorian reflector, which had belonged to his father. In 1859 he became the possessor of an equatorial which had belonged to the Rev. W. R. Dawes, having an object-glass by Alvan Clark of 7½ inches clear aperture and 110 inches focal length, the excellence of the instrument having been seconded under both its owners by unusual keenness of eyesight in the observers. This telescope he mounted at Woodcroft, Cuckfield, and used assiduously. In 1875 he removed to another residence, Knowles Lodge, which he had built for himself, with an observatory attached, and which he occupied until his death.

Mr. Knott was elected a Fellow of the Royal Astronomical Society on November 9, 1860. On December 13, 1861, he contributed his first paper to the Society on the variable star R Vulpeculæ, and from that time until November 1886 some twenty-six papers appear under his name in the 'Monthly Notices.' Most of these deal with double and multiple stars (in some of which he was the first to detect a companion) or with variable stars, giving especial attention to R Vulpeculæ, U Geminorum, and γ Equulei. In 1877 he contributed a memoir, which occupies thirty pages of Vol. xliii., containing a series of micrometric measures of double stars made by him between 1860 and 1873.

In 1868 he was elected to a seat on the Council of the Society, which, with one year's intermission (1887), he occupied until 1891. Since 1886 nothing bearing his name has appeared in the 'Notices,' though until the close of last session he was a pretty constant attendant at the meetings, and always showed the keenest interest in astronomical questions of all kinds.

He was also a member of the Selenographical Society.

Mr. Knott's life was so uneventful and his character so modest and retiring, that they afford but slight material for a biographical notice. He was a man of a deeply religious spirit, and a member of the Congregationalist body. A staunch Gladstonian in politics, he quite recently achieved the distinction of refusing to be made a Justice of the Peace. By the neighbours among whom he had lived so long he was warmly esteemed; and one of them writes: "His pleasure was in bringing brightness into other lives. His generosity was shown to every religious body in Cuckfield, irrespective of creed. The poor have lost a true friend."

Mr. Knott leaves a widow, but no family. B. W. S.

Ephemeris of Jupiter's Fifth Satellite.

The following ephemeris of Jupiter's fifth satellite, published in Ast. Nach. 3253, was computed by Mr. Marth from observations during the second apparition of the satellite made by Prof. Barnard, the last being that of 1893, Nov. 19. The adopted daily rate of motion is 722°·633, corresponding to a period of 11^h 57^m 22^s·60, which will probably be found correct within 0^s·05.

Rectangular co-ordinates are given by the following formulæ:
$x = a \sin(l - L)$ in pos. P+90°, $y = b \cos(l - L)$ in pos. P.

Gr. noon.	P+90°.	*a.*	*b.*	*l*−L.	Gr. time of greatest elong.
1894.	°	"	"	°	h m
Nov. 1......	93·76	55·37	+2·11	8·07	14 41 E.
3......	93·73	55·68	2·12	13·50	14 30
5......	93·70	55·99	2·13	18·95	14 19
7......	93·66	56·29	2·14	24·40	14 8
9......	93·61	56·59	2·16	29·86	13 57
11......	93·56	56·88	2·17	35·34	13 46
13......	93·50	57·16	2·18	40·82	13 35
15......	93·44	57·44	2·19	46·31	13 24
17......	93·37	57·70	2·20	51·81	13 13
19......	93·29	57·96	2·20	57·31	13 2
21......	93·21	58·20	2·21	62·83	12 51
23......	93·13	58·43	2·22	68·35	12 40
25......	93·04	58·65	2·23	73·88	12 29
27......	92·95	58·86	2·24	79·41	12 18
29......	92·85	59·06	2·25	84·95	12 7
Dec. 1......	92·74	59·24	2·25	90·49	11 56
3......	92·64	59·41	2·26	96·04	11 45
5......	92·53	59·56	2·27	101·59	11 34
7......	92·41	59·69	2·27	107·14	11 23
9......	92·30	59·81	2·28	112·69	11 12
11......	92·18	59·91	2·28	118·24	11 1
13......	92·06	59·99	2·29	123·79	10 50
15......	91·93	60·06	2·29	129·34	10 39
17......	91·81	60·11	2·29	134·89	10 28
19......	91·68	60·14	2·29	140·43	10 17
21......	91·56	60·15	2·29	145·97	10 6
23......	91·43	60·14	2·29	151·51	9 55
25......	91·30	60·12	2·29	157·04	9 44
27......	91·17	60·07	2·28	162·56	9 33
29......	91·05	60·01	2·28	168·08	9 22
31......	90·93	59·93	2·28	173·59	9 11 E.

In the same number of the Ast. Nach. is a request that observations of this satellite, hitherto unpublished, may be sent to Dr. Kurt Laves, of the University of Chicago, who is computing an orbit.

Selenographical Notes.

Wichmann.—Most lunar observers are familiar with this brilliant little crater, situated in the Oceanus Procellarum northwest of Letronne. It is remarkable not only for its brightness, but as standing on one of the curious light areas which are so often found associated with small objects of its class, the nature of which remains still in the region of hypothesis. Though probably not more than four miles in diameter, it will be seen, when examined on a good night with a high power, to deviate very considerably from circularity, exhibiting, in fact, very obviously, a rhomboidal shape, the four sides being of a linear type. On the north there is prominent projection from the wall, extending in this direction for several miles, well shown by Schmidt, but not elsewhere, in the form of a narrow bright ridge, nearly as lofty as any portion of the border. A short distance north of the termination of this spur stands Neison's brilliant mountain, ε, with an equally conspicuous and larger triangular-shaped elevation adjoining it on the N.E. This object forms a portion of a large, broken, discontinuous ring, about 30 miles in diameter, which has all the appearance of having once been a complete formation. It is, in fact, more prominent than the well-known mountain ring, adjoining it on the east, N. of Flamsteed, and includes many loftier heights than any which figure on this obscure circumvallation. This portion of the Mare Procellarum abounds in formations of this description, which can hardly be accounted for by a fortuitous arrangement of ridges, as they are to a great extent made up of bright mountain masses of considerable altitude, separated by more or less wide gaps. In addition to the Flamsteed ring, the large ring south-east of this formation, and another incomplete object of the same type south-east of Encke, may be specified as prominent examples of these curious formations. The ring north of Wichmann is best seen when the morning terminator traverses the centre of Letronne.

ENLARGEMENTS OF LUNAR PHOTOGRAPHS.—Through the courtesy of M. W. Prinz, of the Imperial Observatory, Brussels, I have received copies of his beautiful and most successful enlargements of portions of a photograph of the Moon taken with the great refractor of the Lick Observatory, 1891, Oct. 12, $7^h\ 24^m\ 11^s$-14^s P.s.t. They consist of three plates. Plate I. contains the Mare Nubium and the mountains which border it, and includes Copernicus and Plato, enlarged 8 diameters. Plate II. the neighbourhood of Bullialdus and the clefts bordering the west side of the Mare Humorum, enlarged 24 diameters. Plate III. Copernicus with a portion of Reinhold, enlarged 33 diameters. These wonderful pictures, reproduced through the liberality and public spirit of M. le Sénateur E. Solvay, member of the Council of the Brussels University, will doubtless be followed by others of equal excellence, forming ultimately an Atlas of Lunar Topography of great value to the Selenographer and Selenologist.

Vol. III. of the 'Publications of the Lick Observatory,' kindly forwarded me by Dr. Holden, also contains matter of the greatest interest to Lunar Observers, in the shape of the beautiful Selenographical Studies by Dr. L. Weinek, of Prague, based on negatives of the Moon taken at this establishment, and a drawing and description of the apparatus designed and used by him for making these drawings. Among Dr. Weinek's drawings are views of the Mare Crisium, Archimedes, Arzachel, Petavius, Vendelinus, Langrenus, Capella, Taruntius C, and Copernicus, and a magnificent 24-times enlarged view of Tycho by Dr. Weinek and Dr. R. Spitaler. The volume also includes exquisite enlargements of the M. Crisium by Prof. Burnham, of Langrenus, Vendelinus, Petavius, and of the Lunar Apennines, by Mr. Colton, Assistant Astronomer at the Lick Observatory.

Clavius.—The October number of 'Sirius' contains a fine reproduction of a very beautiful drawing of this formation by M. Joh. N. Krieger, of the Privat-Sternwarte Gern-Nymphenburg, under date 1894, July 24, 16^h. It includes far more detail in connection with the walls than any representation of this magnificent object which has hitherto come under my notice, showing about 60 small craters in the interior, and much detail associated with the larger objects therein, and on the walls, which has not been recorded. Schmidt, however, on one occasion saw 90 craters on the floor.

Beaumont House, Shakespeare Road,
Bedford, 1894, Oct. 19.

T. Gwyn Elger.

CORRESPONDENCE.

To the Editors of 'The Observatory.'

Encke's Comet.

Gentlemen,—

As Encke's Comet will be due in perihelion early next February, and will probably become visible in December, a few words on its earliest appearances may be of interest to some of your readers who have not access to the accounts of these. On the second occasion it was discovered by a lady whose name will ever be held in remembrance and respect by astronomers. The first was on the 17th of January, 1786, when the comet was discovered in Aquarius by Méchain at Paris, but observations of it were made only on that day and on the 19th. "Es sind also davon," remarks Méchain, "nur zwei Beobachtungen vorhanden, und daher wird die Bahn dieses Kometen unbekannt bleiben,"—a prophecy which reads oddly now, though for some years it remained true.

Unseen returns must have taken place in 1789 and 1792; but the comet was re-detected as a new one by Carolina Herschel at Slough on the 7th of November, 1795. She had already discovered several comets, the first on August 1, 1786, whilst her distinguished brother was on a visit to his native country. This (still anonymous) comet was observed by him on November 8 and 9; on the latter day it passed centrally over a faint double star north following 15 Cygni without obscuring it. On the 11th of the same month, Bode, having with him at the observatory at Berlin an amateur astronomer from Osnabrück named Carl, they were studying the heavens together with a small telescope when the latter noticed a nebulous object between Lyra and the neck of Cygnus, which Bode at once suspected to be a comet, though it had no tail or nucleus, because he knew of no nebula in that place. He observed it on several nights afterwards, the last on November 24. This was also the date of the last observation obtained at Greenwich, where Maskelyne observed it on November 20, 21, and 24. The latter contested Herschel's conclusion, from the fact of his seeing the comet pass centrally over a star of the twelfth magnitude without obscuring it (Maskelyne could not see the smaller star, making it double), that the comet "is evidently nothing but what may be called a collection of vapours," by suggesting that the nucleus might be situated not in the centre of the coma.

This comet was not seen again until 1805, when it was independently discovered by several observers, the first being Thulis, of Marseilles, on October 19, who also carried on observations of it to a later date than any one else, the last being on November 19. Although the identity of this comet with those of 1786 and 1795 was not yet suspected, Encke thought that the orbit was probably elliptical, and that the period was a little more than 12 years. It was after Pons's re-discovery on November 26, 1818, and the observations made at that appearance, that he was able to determine its true orbit in a way which has ever since linked his name with the comet, though he himself always called it Pons's. His theory that the slow shortening of its period which afterwards took place was the effect of the action of a resisting medium on its motions, has had to be abandoned (unless with considerable modifications) in consequence of the change in its amount; but the real cause has not yet been explained, and the circumstance gives much additional interest to future observations of the comet and investigations of its motions.

Encke's Comet, it may be here remarked, is the only known periodical one which is due to return to perihelion in 1895.

Yours faithfully,

Blackheath, 1894, Oct. 15. W. T. LYNN.

Publication of the "Life, Letters, and Papers" of the late Prebendary Webb.

GENTLEMEN,—

I would be glad if you would allow me to draw attention, in the pages of the 'Observatory,' to the above undertaking which I have in hand. In April last there appeared in the 'British Astronomical Association's Journal' (vol. iv. part 5, p. 216) a letter of mine on this subject, stating that I had begun the endeavour two years before and had been obliged to drop it, but that I had received considerable encouragement then, and that I was now intending to make an effort to carry the undertaking through. I am glad to say I have met with some success, and have been able to make some decided progress in the way of collecting materials. Mr. Ranyard, in particular, has been most kind in the matter from the first; and I have also received valuable aid, either in the loan of letters or in indications of useful sources of information, from Mr. Ward, Mr. Denning, Mr. Mee, Mr. Elger, Mr. G. F. Chambers, Dr. Copeland, and others. My plan includes a short memoir, with letters and a collection of papers of permanent interest. I would be much obliged if any of your readers, who may be willing and able to assist by furnishing letters, reminiscences, references, or indications where further material may be sought, would communicate with me at the under-noted address. Any letters or other MSS. will, of course, be most carefully preserved, and returned as soon as possible. Of course, it will be readily understood that the collection of materials for a work of this kind is both a slow and a troublesome task, and the extensive character of Mr. Webb's correspondence, and the way in which his numerous contributions (many of which are most valuable) to various publications are scattered about, do not render it in this case any easier.

C/o W. L. Wilson, Esq.,
254 St. George's Rd., Glasgow,
1894, Oct. 26.

I am, yours truly,
S. Maitland Baird Gemmill.

The Chinese Astronomers, Hi and Ho.

Gentlemen,—

With reference to the last paragraph on p. 346 of this month's 'Observatory,' it is stated in Rambosson's 'Astronomy,' a work published about 1870, that the Shu Ching alludes to an eclipse of the Sun, which occurred in the reign of the Emperor Chun King, who put to death Hi and Ho, the astronomers, on account of their neglect in observing the phenomenon. "They created confusion in the *celestial chain* and left their functions unperformed." The astronomers Hi and Ho were put to death in conformity with the decree: "Whosoever advances the march of time shall be put to death; whosoever retards it shall also be put to death!"

There is a translation of this work of Rambosson in the Library of the Royal Astronomical Society.

It seems that very severe punishments were inflicted by the ancient Chinese kings on calculators who made mistakes in their observations or calculations.

Walthamstow, 1894, Oct. 4. F. W. Henkel, Jun.

An early unobserved Transit of Mercury.

Gentlemen,—

It may have escaped notice that in November 1664 a transit of Mercury took place under very similar circumstances to the one we are expecting next month; the ingress of the planet on the Sun taking place almost precisely at the same minute, and the duration of the transit itself being almost exactly the same. Although one of the unobserved passages, it was looked out for. In 'Evelyn's Diary' we have the following, under date of 24 October (O.S.):—"I went to visit Mr. Boyle (now here), whom I found with Dr. Wallis and Dr. Christopher Wren in the tower of the schools [*i. e.* at Oxford], with an inverted tube or telescope, observing the discus of the Sun for the passing of Mercury that day before it; but the latitude was so great that nothing happened." It is extremely unlikely that any telescope was applied to the Sun on the American continent. This was not the only disappointment of this sort in the seventeenth century, Horrox having looked out unsuccessfully for a transit of Mercury in 1638, a year and a month before he saw Venus on the Sun. Arago and one or two others give a transit in their lists for November 1901. The planet on the afternoon of the 4th of that month will probably make a very near approach, similar to the case of May 1937, when Professor Newcomb considers it will pass within about 1′ of arc from the solar limb, and may perhaps be perceived on the chromosphere.

Faithfully yours,

S. J. Johnson.

Melplash Vicarage, Bridport,
1894, Oct. 20.

OBSERVATORIES.

[Continued from p. 339.]

Munich. *H. Seeliger.*—Dr. Bauschinger has made 2093 observations of zenith-distance and 520 of the nadir. The observations have been reduced, and point to a small diminution of Bessel's constant of refraction. A series of observations has been begun of stars culminating near the zenith. With the 10½-in. refractor Dr. Oertel observed Saturn on 21 nights, Comet Holmes on 7 nights, and Nova Aurigæ on 5 nights. Meteorology.

O'Gyalla (Hungary). *Von Konkoly.*—Observations of sunspots were made on 204 days. Observations of meteors. Drawings of Jupiter were made at the great refractor. Comet Rordame-Quénisset was observed by Dr. Steiner. Time-service. Meteorology.

Potsdam. *H. C. Vogel.*—Two wedge-photometers have been acquired for use by Profs. Müller and Kempf in an expedition to Etna for observations on the extinction of light in the atmosphere.

160 photographs of the spectrum of β Lyræ have been taken by Dr. Wilsing, and have been discussed by him and Dr. Vogel. More observations are to be taken for the elucidation of the double spectrum of the star.

Prof. Scheiner has been engaged in the comparison of the temperatures of stars of the various spectral classes and of the Sun with that of the electric arc.

A photometric catalogue of stars, from 0° to +20° decl., has been concluded and partly printed. This has been compared with the results of Pickering and Pritchard. Dr. Lohse has taken 151 photographs of the Sun. Dr. Spœrer has made observations of sun-spots on 244 days; in all, there were 1706 groups, or an average of 7 per day.

Prof. Scheiner and Dr. Schwassmann have been investigating the cause of the increase of the diameter of a star's image with lengthened exposure, and consider it to be due to irregularity and strain in the object-glass. Photographs of Orion's belt, with exposures varying from 5 min. to 3½ hrs., have been taken. 270 images on 34 photographs have been taken of the double star 61 Cygni; they show an inequality of $0''\cdot3$ in a period of 22 months due to another companion. Meteorology.

Prague (University). *L. Weinek.*—Prof. Weinek has again devoted over 300 hours to obtaining enlarged drawings of the Lick photographs of the Moon. Most of this time was devoted to Copernicus. In his examination of the photographs he has found several hitherto undiscovered craters, and states that an object on the Moon, of diameter 500 yards, is clearly shown in the photographs. He intends to bring out an atlas of the Moon, on the scale of 10 feet to the diameter.

Dr. Spitaler has made 57 meridian observations of the Moon's limbs and Moesting A, and has completed some subsidiary observations for the determination of latitude by the Horrebow-Talcott method. Oc. dis. B.D. +19°·2215 observed on June 17; Oc. re. δ Arietis, Sept. 1. Time-determinations. Magnetic and meteorological observations.

Strasburg. *E. Becker.*—The heliometer was being repaired by Repsold from Jan. 20–Nov. 8, so that only 20 measures of the Sun's diameter were obtained with it. With the 18-in. refractor Comets Swift, Denning, Holmes, Brooks 1892 VI., Brooks 1893 I., Rordame-Quénisset, Finlay, and Brooks 1893 IV. have been observed in all on 38 nights. 199 places of nebulæ, 91 of comparison-stars, and 2 of planet Thule have been determined.

At the meridian-circle the Sun, Moon, and planets have been regularly observed, as well as a few stars in Zones −2° to −6°, and a large number of circumpolars. With the altazimuth 739 pairs of stars were observed on 81 evenings for the determination of latitude.

Dr. Wislicenus has been comparing the brightness of the Moon at 20 different points, and has made 142 measures. He has also compared the total brightness of the Moon in different phases with that of Polaris.

A series of observations with a horizontal pendulum has been made from the spring of 1892 to 1893 Sept. 4. They give for the resolved part in the meridian of the displacement of the plumb-line by the Moon

$$+0''\cdot00516 \cos(\tau - 248^\circ) + 0''\cdot00520 \cos(2\tau - 196^\circ),$$

while the theoretical displacement is

$$+0''\cdot00798 \cos(2\tau - 180^\circ),$$

τ being the Moon's hour-angle.

No explanation is given of the first term; but from the fact that the observed coefficient of the half-daily term is less than its theoretical value, it is deduced that the Earth's crust has at Strasburg a rise and fall of ± 11 centimetres.

UPSALA. *N. C. Dunér.*—With the new refractor set up in 1892 some trial observations have been made. 503 visual observations of spectra of stars of the third class have been made. A few meridian observations.

VIENNA. *L. de Ball.*—This is a private observatory founded by M. Edler von Kuffner. 7008 stars in the Zone −6° to −18° have been made with the meridian-circle, and the reductions are being carried on.

Dr. Oppenheim has been measuring stars on three photographic plates of the cluster G.C. 1166, and obtains results with a mean error $\Delta\alpha \cos\delta \pm 0''\cdot26$, $\Delta\delta \pm 0''\cdot20$.

ZURICH. *A. Wolf.*—Sun-spot statistics have been collected, as usual. The Sun has been observed on 220 days. Micrometer measures have been made on 180 days and of the protuberances on 149 days. The results for the last three years are:—

	Number of observing days.	Sun free from spots on	Relative numbers.
1891	320	18	35·6
1892	291	0	73·8
1893	297	0	85·5

PUBLICATIONS.

THE PULKOWA STAR-CATALOGUE, EPOCH 1885.—This Catalogue of the declinations of 40 fundamental stars, deduced from observations made with the Pulkowa Vertical Circle, combines the well-known series of the 1845 and 1865 Catalogues of this Observatory. Since the last Catalogue was issued the instrument has been thoroughly overhauled, the Y's repolished, and the circle redivided. The stars observed are the same, with a few additions, as those of the 1865 Catalogue, and the observations have all been made by M. Nyrén. The minimum number of observations of any star is 8, and care has been taken to so spread the observations that the mean is not far removed from 1885. It does not, however, appear to us that 8 can be considered an excessive number of observations spread over 10 years, upon which to establish a first-class fundamental position; we should much have preferred to have found 8 observations in every year. The mean value of the latitude is the same as was used for the 1865 Catalogue, viz. 59° 46′ 18″·54, and the refractions used are also the same, 'Tabulæ Pulkovenses.' For declinations over 45° the places depend on the above and below pole observations. The precession constant used in the reduction is that of M. Struve, and the proper motions those deduced by Dr. Auwers. The observations have been further corrected for periodic variations of latitude, and for variations in the difference between the exterior and interior thermometers, in accordance with M. Nyrén's papers on these subjects. M. Nyrén has convinced himself that the observations would be all the better for the application of two small corrections to the adopted refractions. To the logarithm of the coefficient of refraction he would apply the correction − 0″·00121, making the constant 57″·538, and to the coefficient of the correction for the thermometer he would apply +0″·0001021, making it 0″·0047121 for 1° R., the general effect being to diminish the refractions. As a support for this alteration he gives comparisons of the 1865 and 1885 star-places with and without the corrections; but as in a previous part of the introduction to the volume he has expressly stated that he considers the 1865 Catalogue is open to the grave objection that its places depend on too few observations, it seems somewhat surprising that he should finally appeal to its judgment in so important a matter. W. G. T.

THEOPHRASTUS ON WINDS AND WEATHER-SIGNS*.—It is usually asserted that Astronomy is the oldest of the sciences; it does not seem unreasonable to suggest that Meteorology may be the elder of the sisters. Mr. G. J. Symons has for some time been making praiseworthy efforts to unearth the earliest literature of this subject and to present it in an easily legible form. The first-fruit of his efforts now lies before us.

This is a translation by Mr. J. G. Wood, M.A., F.G.S., of two pamphlets written in Greek by Theophrastus, the favourite pupil of Aristotle (translations of Aristotle's Meteorology exist, but are very scarce), who was born about the year 374 B.C. and lived in Athens until 287 B.C., to which city the meteorological observations must be taken to apply. The first of these on "Winds" is a treatise on the effects of, and phenomena concurrent with, certain winds. It is rather to be regarded as a record of observations than as a description of theories to account for the cause of winds; in fact when Theophrastus attempts to ascribe causes, he is at times hopelessly at variance with present day ideas, as, indeed, might be expected, remembering, as Mr. Wood says, that at his epoch "the rotation of the earth about the sun was as yet a dream or a theory to be disclosed only to a select few, and to whom the nature of heat and the composition of the gaseous, fluid, and solid forms of matter were absolutely unknown": as an instance of this false reasoning we might mention that the reason why winds are warm in summer but cold in winter is given by Theophrastus as analogous to the reason why the breath emitted from the mouth is sometimes warm and sometimes cold, and that both effects are due to the *manner* of emission; but there is no explanation of the assumption that the terrestrial air passes through a channel analogous to the lips confined in winter and broadened in summer. We quote this as an example of, and not as a blemish on, the book, in which one would scarcely look for theories, but rather for historical observations.

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* 'Theophrastus of Eresus on Winds and on Weather-Signs.' Translated, with an introduction and notes and an Appendix, by Jas. G. Wood, M.A., LL.B., F.G.S., and edited by G. J. Symons, F.R.S. London: Stanford, 1894.

The other paper, on "Weather-signs," is a categorical collection of signs and portents which foretell rain, winds, storms, fair weather, and the kind of weather to prevail in ensuing seasons. Theophrastus makes the statement, which holds its ground with some to the present day, that changes of weather take place at certain epochs of the year, month, or day. The annual rising and setting of the Pleiades, the Equinoxes, and Solstices thus divide the year, while for the months the times of change are the times of full and new moon and of the quarters and fourth days, *i. e.* the third day before or after the day of any of the quarters, making with such day the *fourth* day. Similarly for the days, the epochs of change are sunrise, forenoon, noon, afternoon, and the sunset; not that it is meant to imply that changes necessarily take place at these times, but that "if the weather is going to change, it generally changes at such divisions."

Many of the portents are familiar to us of the present day. As signs for rain we find given, "the red sunrise," "birds washing," "frogs croaking;" and as the sign of a stormy year, "the appearance of many jelly fish in the sea," but we have heard this given by sea-faring folk as the sign of a hot summer, and again "many berries on the scarlet oaks indicate a severe winter." There are some curious signs: "An ox resting on his left thigh indicates fair weather, and the dog likewise, but lying on the right indicates a storm," which shows a nice distinction on the part of these animals, for which it is not easy to find a reason.

There are a few signs of an astronomical nature; one of them runs, "Black spots on the Sun and Moon indicate rain: red show wind," which may or may not be a very early record of sun-spot observation.

The above extracts will show that the book is of considerable general interest; not the least interesting part is the Appendix by Mr. Wood on the Direction and Nomenclature assigned to winds in classical literature. Mr. Symons is to be congratulated on his collaborator, who, as we learn from the preface, was but one of four who volunteered for the task of translating the papers in response to a request by Mr. Symons in his Magazine for July 1892.

LICK OBSERVATORY PUBLICATIONS[*].—We have before us the two volumes recently issued from the Lick Observatory. These volumes deal with widely different subjects and are certainly well calculated to enhance the high reputation of the Observatory. Volume II. contains the double-star measures and discoveries made with the 36-inch and the 12-inch Clark refractor in 1889–90 and 91 by S. W. Burnham. These have been published before, but are here collected in compact form and freely annotated. Besides the measures of known pairs from 1888 it contains Burnham's 14th, 15th, 16th, 17th, 18th, and 19th catalogues, and his work on double-star orbits. In fact for recent knowledge in double-star work this volume is indispensable and we congratulate Prof. Burnham.

Volume III. contains the results of an immense amount of work on several subjects. First we have the selenographical studies based on negatives of the Moon taken at the Lick Observatory. These are by Dr. Weinek, of Prague, and are prefaced by an introduction by Prof. E. Holden. The Lick photographs are so well known now that it is superfluous to say anything about them; especially too as these have been treated of by Mr. Elger in our own Selenographical Notes in this number; but we cannot refrain expressing some admiration for the enlargements which are freely inserted in the volume. Following the Lunar portion there is a "Report on specimens of crown and flint glass belonging to the Lick Observatory, and manufactured by Messrs Feil," by Dr. C. S. S. Hastings; "Keeler's Spectroscopic Observations of Nebulæ, Planets, and Stars."

A JOURNEY IN OTHER WORLDS[†].—This is a book, partly astronomical, of the type with which Jules Verne has made us familiar: a book full of improbabilities and of twisted-about science, which gives an air of possibility to the whole. This sort of thing does no harm. Under the guise of light literature it is calculated to set its readers thinking on subjects which do not generally come under that head, whilst the improbabilities are so apparent that they are not likely to mislead. Let us to the book itself.

The epoch of the story is the year 2000 A.D., the place America, at least in the beginning: the world at this period does not seem so much changed in its habits as some would-be reformers of the present day would wish it to be, *e.g.* the lady is not particularly *new*, people are certainly not all teetotallers, courtship is conducted in much the old style, there are still theatres, and the company promoter still exists. Mr. Chambers will be glad to hear that he has achieved immortality, as far as the year 2000 at any rate; his name appears to be a household word at this period, as *the* astronomer of the end of the nineteenth century. The changes appear to be chiefly in mechanical and electrical science, which have developed enormously. There are two big pieces of work on hand in these branches—one, run by a company, for "straightening the Earth's axis," which appears to mean setting it perpendicular to the ecliptic that there may be equable climate throughout the year at every place, and every man may choose his own climate. How this is to be accomplished by pumping out the Arctic Ocean and otherwise altering the configuration of the Earth must be read in the book itself. The other scheme has for its object the colonization of the other planets, and it is discussed whether communication shall be made by altering the eccentricity of the Earth's orbit so that the Earth should run against the other planets, or whether it shall be managed by aerial vessels propelled by a newly discovered force called "apergy," which appears to be the correlative of gravitation. The latter scheme prevails; and the major part of the book consists of the history of the journey made by three men in a car called the 'Callisto,' propelled by "apergy" to Jupiter and Saturn. The journey to Jupiter is uneventful enough, the steering is all managed very nicely, as always happens in these books, so that the travellers had a good look at the Moon and Mars and so on, while Dr. Cortlandt, who was the oppressively well-informed man of the party, added to the general gaiety by obliging with such remarks as "Pallas was discovered by Olbers in 1802," and with little astronomical discourses having openings such as: "Until Prof. Hall discovered Mars' satellites," &c.—which must have tempted his hearers to push him off the car without his apergetic outfit. The things they find on Jupiter—giant ants, immense snakes, and animals of the Pliocene period—and how they managed to kill them, must be read of in the book itself. Our travellers thence betake themselves to Saturn, which they find to be the abode of departed spirits. They make the acquaintance of the spirit of a colonial bishop, who not only gave them some advice in the matter of carrying on the axis-straightening business, but also asked them to dinner. This part of the book is devoted mainly to moral and theological discourses befitting the place and the acquaintanceship of a bishop, with which we do not propose to deal, but after saying that the travellers get safely back to Earth and the wedding takes place, we think we have said enough to show what style of book this is. We, however, think it our duty to point out three of the astronomical mistakes we have noticed, as instances of the ease with which mistakes may be made and passed over in writing a book of this kind:—(1) The travellers, when on Jupiter, saw his moons rise one after the other in the space of a few minutes, *in different phases*; (2) When on Saturn, *at midnight*, they saw the Earth in the zenith; (3) It is doubtful whether the *new* Earth is a naked-eye object from Jupiter. The book is worth reading if the astronomy is skipped and the rest not taken too seriously.

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[*] 'Publications of the Lick Observatory,' vol. ii. 1894, and vol. iii. 1894.

[†] 'A Journey in Other Worlds: a Romance of the Future.' By John Jacob Astor. Longmans, Green, & Co. (London, 1894).

CELESTIAL OBJECTS FOR COMMON TELESCOPES *. VOL. II.—The second volume of the fifth edition of Webb is now before us, and we confess to a little disappointment. The great fault of Vol. I. consisted in putting all new matter in the form of notes; this has not been done here, and the advantage is very apparent. The revision and bringing up to date of so many observations is no light task, still we are inclined to think that the measures of double stars might have received greater attention. First we think that, where a star has changed in position-angle over 10° or in distance 1″ since its discovery, the latest measure ought to be given in preference to that of the time of discovery. Again, where both an old and a modern measure are given, the latter ought to be *later than* 1885, if possible. As examples we would note:

Σ 2928, marked as Bin.?, 327°·7, 4″·7, ought to have two sets of measures, because an observer seeing *Bin.* would like to know in which direction the motion was. The measures 1892·8 were 315°·8 and 4″·2.

Σ 2434, instead of the '85 measures should have one at least 1890 (a change of 9° in the 5 years).

Σ 113, measure of '86 ought to have been '93.

Σ 2052, Bin. 99°·2, '84, certainly would look better as 98°·5, 2″·2, '90.

These are sufficient to show our point; but even this fault is not so great as in some well-known stars.

Σ 73 is given as Bin. 137·5 years, and the latest measure that of '89, when the measures in the paper giving the period read down to '91.

Σ 228, given as rapid Bin., might have added to it: orbit by Gore, period 88·7 years; also 156°·2 ought to read 336°·2.

Σ 208, γ Androm. 318°6 ought to read 312°·6, and Burnham makes period 54·8 years.

β 1212. A note ought to have been added to the effect that the angle varies some 9° annually, and the date of the measure ought to be given '91.

Σ 2084. Most remarkable Binary, with mutual occultation, mags. 3 and 6·5. Distance varies from 0″·6 to 1″·6. How can this be?

Faults of this class do not materially affect the book, as they can be remedied; but it is different in the case of the "Index to double stars which have no letter or number assigned by Bayer or Flamsteed."

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* 'Celestial Objects for Common Telescopes.' By the Rev. T. W. Webb, M.A., F.R.A.S. Vol. II. Fifth edition, revised and enlarged by the Rev. T. E. Espin. Price 6*s*. 6*d*. Longmans, Green, and Co.

A double star of great catalogues, such as Σ, OΣ, β, ought, in our opinion, to be indexed according to the number of its catalogue, with the addition of the Bayer or Flamsteed title, if you like. How many double-star observers would look for Σ 2315 under the title of 452 Herculis? Take the case of this star. We first looked at the index—not there; then turned up our own record and found it 452 Herculis. Looked under Herculis—not there; now there is a lurking doubt in our minds. Is it in Webb? It is an interesting pair which has varied from 281° and 0″·6 in 1830 to 222° and 0″·3 in 1890. A very little extra trouble would have been required to make the index complete and useful, whereas at present it is calculated to waste time. Other stars, such as Σ 2400 (305° and 3″ in 1828, 193° and 2″ in 1885), Σ 2438, Σ 2454, &c., are not in the index, and we cannot find them. Similarly β 581, a fine triple close pair having period of about 51 years—closely resembling ζ Cancri (see M.N., April 1892)—may be in the book somewhere, but the index does not assist us, nor does it in the case of OΣ 82, a binary of 90 years' period. By the way, there appears to be some mistake about *p* Eridani in the list of Southern Doubles. What can be the idea of giving the measures as 122° and 3″·6 when they really were in 1892, 228° and 7″·5?

Such errors as we have pointed out are inseparable from a book of this kind, and would perhaps pass unnoticed but for the high standard which the work of Webb has attained in the regard of astronomers, and they must be viewed in that light. We heartily recommend both volumes as containing a mass of technical and popular information not met with in any other single work.

NOTES.

The Coronal Comet of 1893, April 16.—We are glad to publish Mr. Wesley's article on the comet discovered by Prof. Schaeberle on the photographs taken during the eclipse of 1893, April 16, and trust that our note on this subject in number for July last was not taken as implying any doubt of the reality of the comet, but merely as a statement of fact that the object was not readily visible on the English photographs, which we felt justified in making, knowing Mr. Wesley's skill and experience in the treatment of coronal photographs. We offer Prof. Schaeberle our sincere congratulations, and feel some satisfaction that the English and American observations are now in accord on this point.

Comet Notes.—In 'Comptes Rendus,' No. 14, there is an interesting paper by M. Callandreau on Dr. Backlund's recent researches on Encke's Comet. This comet offers the best means of obtaining the mass of Mercury, which is now deduced as

$\frac{1}{9,700,000}$, with a probable error of only 1 per cent. The mass previously adopted by Newcomb was $\frac{1}{7,500,000}$. The resulting density of Mercury is 0·65 of the Earth, the latter having the greatest density of any body in the solar system. The acceleration of the comet's mean motion appears to have been uniform from 1819 to 1865, then to have been reduced to half its amount, and again remained uniform till 1891. The observations do not appear to admit the idea of a continuous resisting medium (we should have to suppose its density to increase outwards from the Sun, which is inconsistent with the motion of other comets); the conclusion is that it is localized in certain regions.

Dr. Spitaler has published definitive elements of Comet 1851 III. (Brorsen). The comet was discovered 1851 Aug. 1, and was observed on 41 nights at 18 observatories, the last observation being on Sept. 30. The following are the most probable elliptic and parabolic orbits:—

T =	1851 Aug. 26·249997	1851 Aug. 26·252300 Paris M.T.	
π ……	310° 57′ 19″·15	310° 57′ 25″·69	1851·0.
☊ ……	223 40 33 ·90	223 40 21 ·21	
i ……	38 12 52 ·91	38 12 57 ·46	
log q ….	9·9933235	9·9933272	
e ……	0·9999151	1·0000000	

The period implied by the elliptic orbit is 1,126,000 years.

A. C. D. C.

Nebulosity in the Neighbourhood of the Pleiades.—For years past Prof. Barnard has been aware of the existence of appearances of nebulous matter in the region around the Pleiades, but exterior to the area enclosing the well-known nebulæ photographed by Roberts, the brothers Henry, and others. In Ast. Nach. 3253 Prof. Barnard says: "To the north of the Pleiades, from $\alpha = 3^h\ 20^m$ to 4^h and beyond, and from $\delta = +30°$ to several degrees further north, is a region singularly devoid of small stars, but covered with large masses of very diffuse nebulosity; this part of the sky will attract the attention of any one in sweeping over it with a very low power on an ordinary telescope. The field is dull with feeble nebulosity." This appears to mark the limit of the nebulæ in a northern direction, but much nearer to, and around the Pleiades as a centre, is much nebulosity in curves and streaks. Last winter Prof. Barnard, using the Willard lens, contrived, by continuing the exposure for two nights 1893 Dec. 6 and 8, and carefully covering the lens between the two periods, to expose a plate to this region for $10^h\ 15^m$ in all, which showed the nebulous matter as described. A drawing from the photograph thus obtained accompanies the number of the Ast. Nach. mentioned above.

THE CHANGES IN THE SPECTRUM OF β LYRÆ.—An excerpt from the 'Proceedings of the Royal Society,' vol. lvi., by Prof. J. N. Lockyer, gives us the latest conclusions with respect to this remarkable star, which has received much attention from eminent observers—Belopolsky, Vogel, Keeler, Sidgreaves (who published an interesting account of his spectrographic observations in Mon. Not. R. A. S. for December last), and others. It will be remembered that the period of this variable is about twelve days twenty-two hours; there are two approximately equal maxima of mag. 3·4, a principal minimum of mag. 4·5, and a secondary minimum of 3·9, the period of variation given being that which elapses between two successive principal minima.

Prof. Pickering some years ago began to examine the spectrum of this star photographically, the dark and bright lines in which change their relative position according to the phase of the variability of the light, giving rise to the conclusion that the star is a binary, and a short account of his results was published in these pages, vol. xiv. p. 341. At his request Prof. Lockyer continued the work at Kensington, and now publishes a preliminary *résumé* of his results. We take leave to transcribe here his conclusions as given:—

1. The spectrum is constant at the same interval from principal minimum.
2. The kinds of variation shown on the photographs are as follows:
   (*a*) Periodical changes in the relative intensities of the lines.
   (*b*) Periodical doublings of some of the dark lines.
   (*c*) Periodical changes in the positions of the bright lines with respect to the dark ones.
3. There are two bodies involved giving dark line spectra.
4. The maximum relative velocity of the two dark line components in the line of sight is about 156 miles per second.
5. One of the dark line components bears a strong resemblance to Rigel and the other to Bellatrix.
6. When the two bodies lie along the line of sight, partial eclipses occur. This happens near the minima of the light curve.
7. In addition to dark lines there are several bright ones which change their positions with respect to the dark ones.
8. The bright lines are brightest soon after secondary minimum.

DR. NORBERT HERZ kindly sends us the following description of a method he proposes for determining the changes of level and azimuth errors of a meridian circle during an evening, which we have ventured to put in our own words for purpose of publication.

In both of the ends of the axis of a meridian instrument lenses of equal focal length are fixed. Exterior to the axis, and in a line with it, are placed, at one end a mark, at the other a microscope with micrometer. The levels in the axis thus produce an image of the mark in the field of the microscope. As the axis of the instrument changes in azimuth or in inclination, the image of the mark undergoes a change in position, which may be measured by the micrometer.

We omit the optical formulæ which Dr. Herz gives, and from which he deduces the following example:—If we have an axis of 75 cm. length, and put lenses of 30 cm. focal length in each end, and at the distance of 150 cm. from one lens a mark, and a micrometer at the same distance from the other. Then for a change of inclination or of azimuth of 1", the change of position of the image will be 0·02 mm., which can be measured quite easily. If we take 35 cm. as the focal lengths of the lenses, the change of position of the image corresponding to a change of 1" in position of the axis will be 0·06 mm. The greater the distance between the mark and the micrometer the less will any accidental small movements of the mark affect the result.

ATTEMPT TO DETERMINE THE DATE OF THE 'RIG-VEDA' BY ECLIPSES.—Herr Ginzel has recently made some further investigations into ancient eclipses; the most interesting of which is an attempt to determine the age of the Rig-Veda by solar eclipses, to which reference appears to be made in those Indian sacred poems. In extending the elements of these phenomena to several centuries anterior to those included in Oppolzer's 'Canon,' he has been much assisted by the tables of Herr R. Schram. For the interpretation of the passages in the Rig-Veda he is indebted to Prof. Ludwig, who first called attention to the fact of the mention of four eclipses in different parts of it. Between B.C. 1200 and 1400 Herr Ginzel found that three very large (almost or quite total) solar eclipses would have been visible at Lahore and fairly correspond to the circumstances, so far as they could be gathered, of those mentioned in the Rig-Veda. These occurred at sunrise on March 4, B.C. 1250, about noon on November 17, B.C. 1301, and in the early morning, soon after sunrise, on the 28th of November, B.C. 1386. But the *magnum opus* was to identify the fourth of the eclipses mentioned. Prof. Ludwig believed himself able, on the authority of another ancient Indian writing, to fix its date as the third day before the autumnal equinox, which in that age would fall in the first week of October; and from the description it may be inferred that it took place in the forenoon, whilst Prof. Ludwig thinks that the place of observation may have been some distance to the south or east of the Punjab. Carrying his calculations, by the aid of Schram's tables, back to B.C. 2000, Herr Ginzel found one eclipse, and one only, which appeared to fit all the circumstances of the case. This occurred on the 5th of October, B.C. 1978; and on making as accurate a calculation as was possible, he found that the central line passed from the neighbourhood of Bombay to that of Madras, and that at Lahore nearly 7 digits of the Sun would be eclipsed. But another difficulty cropped up. From the way in which this last-mentioned eclipse was inserted in the text, Prof. Ludwig considered that instead of being much earlier than the other three, it really was subsequent to them. It appears, therefore, either that the statement that it occurred three days before the autumnal equinox cannot be trusted, or the three other eclipses took place before B.C. 2000. Herr Ginzel seems to prefer the latter alternative, which would require further investigations. These questions obviously have a bearing on our knowledge of the lunar acceleration. W. T. L.

Has anyone ever come across any record of a magnificent comet visible in the Southern Hemisphere towards the end of the 18th century? We have lately had brought to our notice a translation of an account, which occurs in the legends of the island of Fiji, of an object not recorded in the usual reference-lists of comets. The account runs:—"When dawn was near, they (the forefathers of the Fijian people) saw a three-tailed star rise above the horizon. The appearance of the comet itself was presaged by an unusual brightness in that part of the sky, the comet itself showing very soon thereafter. The middle tail was the largest of the three, and its brilliancy was similar to the hues of a rainbow. The other two tails, on the right and left of the major one respectively, were of less magnitude but equal to each other, and their brightness was simple white light only. The comet remained visible for thirty-seven nights, after which our forefathers saw it no more. They credited it with being an omen calculated to indicate the approaching death of a great chief."

It happened that a chieftain did die shortly after, from which fact it has been deduced that this appearance happened within the last twenty years of the eighteenth century; but if any one is able to supply the exact date, it would be of interest to certain gentlemen who are engaged in an official enquiry into some matters in Fiji, as it would possibly fix the date of a certain plague which devastated the island.

British Astronomical Association.—The following Officers and Council have been elected to serve for the ensuing session:—*President*, Mr. E. Walter Maunder; *Vice-Presidents*, Dr. A. M. W. Downing, Dr. W. Huggins, Mr. A. C. Ranyard, Rev. W. Sidgreaves; *Treasurer*, Mr. W. H. Maw; *Editor*, Miss A. S. D. Russell; *Secretaries*, Miss Everett, Mr. James G. Petrie. *Directors of Sections*: *Sun*, Miss Brown; *Moon*, Mr. T. G. Elger; *Mars*, Mr. B. E. Cammell; *Jupiter*, Rev. W. R. Waugh; *Saturn*, Rev. A. Freeman; *Comets*, Mr. W. E. Plummer; *Meteors*, Mr. H. Corder; *Star Colours*, Mr. G. F. Chambers; *Variable Stars*, Mr. J. E. Gore; *Double Stars*, Mr. G. M. Seabroke; *Spectroscopy*, Mr. J. Evershed, junr. *Other Members of the Council*, Mr. T. W. Backhouse, Miss Agnes M. Clerke, Mr. P. F. Duke, Mr. W. S. Franks, Sir Howard Grubb, Mr. Edwin Holmes, Mr. C. E. Peek, Dr. Isaac Roberts, Mr. H. Sadler, Mr. W. H. Wesley.

UNITED STATES NAVAL OBSERVATORY, WASHINGTON.—It appears that for some time past a re-organization of the higher staff of this establishment has been under the consideration of the United States Government, and that there has been some feeling that a civilian astronomer should be appointed as Director. We learn from the 'Washington Post' of Sept. 22 that the new scheme settled by the authorities still leaves a naval officer as superintendent of the establishment as a whole, and that the establishment is divided into two branches—one, purely astronomical, of which Prof. Wm. Harkness has been appointed Director, with full control of, and responsibility for, the astronomical instruments and the work done with them; the other branch, the nautical, embraces in its scope the work done in connection with (1) chronometers and the time-service, (2) nautical instruments, (3) magnetism and meteorology—each of which departments is placed in charge of an officer who reports to the Superintendent of the observatory.

MESSRS. MACMILLAN have in preparation a 'Popular History of Celestial Photography,' by Mr. R. A. Gregory and Mr. Albert Taylor. The work will contain a complete account of the application of photography to astronomy, and reproductions of many of the results obtained. There will be twelve sections, as follows:—Instruments of observation; nebular photography; star-clusters and the Milky Way; the international photographic chart; general stellar photography; sidereal spectroscopy; solar photography; eclipse photography; solar spectroscopy; lunar photography; photography of planets; comets and meteors. No similar work has yet been published, though Rayet, Radau, Russell, and others have written more or less condensed summaries of the ground covered.

CORRECTION: "THE LOWELL OBSERVATORY."—In our September number, in correcting a mis-statement with respect to this observatory, we ourselves made an error. The director of this institution is not Prof. Pickering, as stated, but the founder, Mr. Lowell, is in charge, and, as mentioned in our September number, has already published observations. His address is—"The Observatory, Flagstaff, Arizona."

OCTOBER is notoriously a rainy month; the weather of the past week has been some evidence in this direction, for the total rainfall at Greenwich during the 8 days, from midnight Oct. 23 to midnight Oct. 31, amounted to 3·15 inches. The average for the month of October, as taken from the Greenwich records for the 50 years ending 1890, is 2·81 inches. The rainfall for the whole of the month just past is not exceptionally heavy, the record amounts only to about 4 inches, whereas there is on record a month, October 1880, when the total reached 7·65 inches.

We regret to have to announce the death of Dr. Ludwig Schwarz, which took place on Sept. 29 last. The deceased gentleman, who was 73 years of age when he died, was formerly Director of the Observatory of Dorpat, Russia, which office he resigned in the year 1891.

We also have to record the death of Mr. Edwin Clark, C.E., of Great Marlow, who was best known as an engineer, but was also an old member of the Royal Astronomical Society.

As it may be of advantage to some of our readers, we call attention to Mr. Quaritch's announcement in our advertisement pages. He is selling the books which formed the late Dr. De La Rue's library, including many rare star-catalogues and records of observations, copies of which do not often come into the market.

From an Oxford Note-Book.

The appearance of a new volume (VII.) of Cayley's collected papers reminds us of the magnitude of this wonderful piece of work. The Cambridge University Press offered to undertake the publication in 1887, and seven large quarto volumes of about 600 pages each have now been produced, including 485 papers and memoirs. And this is apparently not much more than half! for it only brings the work from 1841 down to 1872, and there are yet twenty years more! The present volume contains a series of astronomical papers—lunar and planetary theories, attractions, and solar eclipses—which appeared in the 'Monthly Notices' and 'Memoirs' between 1862 and 1872. Astronomical papers previous to these are all contained in Volume III. There are half a dozen more from the 'Monthly Notices' to come, but nothing of great importance. Of the whole series, the memoir on the "Determination of the Orbit of a Planet from three observations," and that "On the Graphical Construction of a Solar Eclipse," which immediately follows it in Vol. VII., are of the most general interest. A beautiful portrait, drawn by Mr. Lowes Dickenson in 1893, forms the frontispiece to Vol. VII., a portrait by the same artist in 1874 having appeared in Vol. VI.

The President of the Royal Photographic Society (Sir H. T. Wood), in his recent address, said that—"He felt that the Royal Photographic Society ought to occupy towards the allied bodies the same position that the Royal Society held to the other scientific societies, and that every advance in photographic knowledge ought, as a matter of course, to be brought before it just as every important advance in general science was recorded in the 'Philosophical Transactions,' whether or no it came before the special society—chemical, physical, astronomical, or other—with which it was directly concerned." It may be questioned whether in both cases the wish is not father to the thought; but the notion is a good one to keep in view.

It is healthy occasionally to "see ourselves as others see us," and a writer in the last volume of *The Yellow Book* has set down in unmistakable terms her (for it is "a Woman" who writes) estimate of the value of astronomical research. The article is the first one in the volume; is entitled "Women—Wives or Mothers"; and after some very plain-speaking, in carefully written English, on rather delicate topics which do not concern us (*pace* the writer of the article), the practical conclusion is arrived at that there is a redundant female birth-rate, and that it ought to be stopped. There, however, the writer is at a loss; the proper method of stopping the evil is not obvious, and this is the fault of men of science. "We are, alas! science-ridden, and are likely to remain thus bridled and saddled for many years to come. Every bush and every bug grows its own specialist, and yet we, the patient, the long-suffering public, are left to endure both the fogs that make of London one murky pit, and the redundant female birth-rate which threatens more revolutions than all the forces of the Anarchists in active combination. Meanwhile these devotees of the abstract play about with all sorts of trifles, masquerading as grave thinkers, hoping thus to escape their certain judgment-day. The identification of criminals by the variation of thumb-prints is a pretty conceit: so too is the record of the influence of the moon on the tides, which, we are informed, employs all to itself a whole and highly paid professor, with a yearly average of three pupils at Cambridge. But what are these save mere fads, on a par with leapfrog and skittles, in the presence of the momentous problems about and around us? Let these gentlemen-jockeys look to it. The hour is not far distant when public opinion shall discover their uselessness and send them about their business."

Many and various have been the demands rcently made by stray members of the female population; but the above hint that an astronomer had better hurry up and control the redundancy of It, the female population itself, or he may lose his job, is perhaps one of the most curious.

As regards fogs, however, which perhaps do concern the astronomer, I should like to hear more of a new discovery which, according to an article in *The World* for Sept. 26, "may be confidently expected to conquer smoke." *The World* truly remarks that "in the interests of suffering humanity the earliest and widest publicity should be given to the invention"; and as the matter is not without astronomical interest, as remarked above, I here reproduce the description of the system proposed by Col. Dulier, C.B., which "can be established at a great factory for £50, and in a single dwelling-house for as many shillings; and where houses are of like elevation the apparatus would serve for a whole street or terrace. Colonel Dulier was inspired in the Underground Railway. He observed that the engine-smoke, when it met by chance a jet of steam from the boiler, did not pass away, but, gaining a new and clinging consistency, remained adherent to the walls of the tunnel. On this he based a theory which he has now put into scientific practice. Smoke, when saturated with steam, comes completely under command; it is a positive product easy to manipulate, and only the simplest apparatus is needed to definitely dispose of it, or rather its most deleterious constituents, before it enters the atmosphere. The Dulier process may be very briefly described. The smoke passes from the furnace or fire into a chimney shaped like the letter N, and, entering at the left-hand end of the letter, is there met by a small jet of steam, which saturates the smoke and accelerates the upward draught. At the top of the letter, continuing the simile, another jet of water, in a spray, drives the smoke down to the bottom, where the soot and noxious products are precipitated, while an almost perfectly pure vapour escapes up the last limb of the N. The advantages of this treatment are obvious. It has been proved to the complete satisfaction of chemical experts that more than half the sulphurous acid, so hurtful to breathing, so injurious to vegetation, is thus removed, and with it nearly ninety-four per cent. of the soot. Moreover, it is intended that these elements, so deleterious in the air, should be sent into the drains, where they give invaluable assistance as disinfectants. There is also a marked gain as regards the quantity of fuel expended: in dwelling-houses half the heating value of the coal no longer goes up the chimney. But there can be no saving on the products of combustion, for it is now shown by careful analysis that there is nothing to be got out of any manipulation of soot as fuel."

Last year's clear skies and this year's cloudy ones would perhaps make a fair average year between them. Mr. Clement Scott vividly described, a week or two ago, a sample of this year's weather in Worcestershire. "All nature had changed to the minor key. Damp hens crouched under soaking hayricks. The ungathered harvest lay rotting and sprouting in the deserted fields." It makes one feel damp to read it. "For all this sudden wave of depression," he goes on, "we had only to thank the vengeful St. Swithin and the last fatal moon." This reminds me of some paragraphs, nearly 40 in all, which were collected in a weekly paper the other day under the heading "Weather Wisdom," of which the following are specimens:—

"Sun-spots, now believed to have an effect on meteorological phenomena, were first observed in 1611."

"When pigs are seen carrying straw in their mouths, the omen is favourable for a change of weather."

And yet "Every civilized nation of the world, even China and Japan, now has a Weather Bureau!"

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

No. 221. DECEMBER. 1894.

MEETING OF THE ROYAL ASTRONOMICAL SOCIETY

Friday, November 9, 1894.

Capt. W. de W. Abney, C.B., F.R.S., *President*, in the Chair.

Secretaries: Prof. H. H. Turner, M.A., B.Sc., and
E. W. Maunder.

Mr. Maunder read the Minutes of the last Meeting, which were confirmed.

Mr. Maunder. There is always a very large number of presents to announce at the November meeting, in consequence of the length of the recess; and on this occasion there is a particularly large number, many of them of special importance and interest. In the department of pure mathematics we have received from the Delegates of the Clarendon Press the Mathematical Papers of Prof. H. J. S. Smith, edited by Dr. J. W. L. Glaisher; from Prof. Cayley, Vol. VII. of his Mathematical Papers. In the department of fundamental astronomy we have the Radcliffe Catalogue of 6464 stars for the epoch 1890, founded on observations made during the years 1880 to 1893 under the superintendence of Mr. E J. Stone; also a new volume of the Cordoba Durchmusterung, extending from 22° to 42° S. dec., with 12 maps. These maps contain three times as many stars to the square degree as are contained in the similar maps of Argelander and Schönfield of the northern hemisphere, the Cordoba observers having included a magnitude fainter than was given by Schönfeld and Argelander. In the department of astronomical photography we have received a large number of valuable presents. From Dr. Roberts we have received his beautiful volume of photographs of stars, star-clusters, and nebulæ. Besides our best thanks to Dr. Roberts for the work he has done in photographing star-clusters and nebulæ, I think we owe him a special debt in that he has not been content with taking them for himself, but has placed them within the reach of everyone of us by publishing these beautiful pictures. Dr. Roberts has also presented to the Society twenty-four lantern-slides, copies of some of his most beautiful photographs. Mr. E. E. Barnard has presented to the Society a large number of transparencies on glass of photographs of comets and star-clusters which he has taken at the Lick Observatory. Perhaps the most interesting amongst the cometary photographs are those of Brooks' Comet showing the remarkable break-up which took place on Oct. 20, 21, and 22 last year. I think it is worthy of note that these transparencies which Mr. Barnard has given us are copied by his own hands, because he has no assistant at the Lick Observatory, and whatever reproductions have to be made he has to do himself. Then we have a number of photographs by the late Dr. De La Rue presented by his son. Many of these are of very special interest. There is a series of original negatives of Jupiter and Saturn, and a large positive on glass of the Moon taken in 1860. We have also a number of enlargements by Dr. W. Prinz (of the Brussels Observatory) of photographs of the Moon, taken at the Lick Observatory. Then we have Dr. Galle's Catalogue of Cometary Orbits, brought up to 1894. In the department of solar physics we have a memoir by Mr. Wilson and Mr. Gray on the effective temperature of the Sun. From the Lick Observatory there are two important volumes. Vol. II. contains Mr. Burnham's double-star observations made with the 36-inch and the 12-inch refractors at the Lick Observatory. Vol. III. consists of Weinek's researches on photographs of the Moon taken at the Lick Observatory. We have also had presented to the Society by the Paris Academy Vol. X. of La Place's complete works, and Mr. Knobel has presented to the library a volume of Robertson's Conic Sections, which is especially interesting, as it contains a large number of manuscript notes and additions by Francis Baily. Then we have Vol. II. of Mr. Espin's edition of the well-known handbook, Webb's 'Celestial Objects.' These are some of the most important presents that have been made to the Society. The list is a very full one.

Dr. Downing. I should like to add my mite of commendation to what has fallen from Mr. Maunder with regard to the Radcliffe Observatory Catalogue, published by Mr. Stone. Judging from the number of stars in the catalogue the work is a remarkable one, and from the point of view of quality I have no doubt it will prove to be on a par with what has been previously published by Mr. Stone. I think it will take rank with the other catalogues of northern stars, with which we are all familiar and the value of which we all acknowledge.

A vote of thanks was passed to the donors of presents.

Rev. W. Sidgreaves, in introducing a paper entitled "Notes on Solar Observations at Stonyhurst College Observatory," said:—I have written the paper on the principle that whatever anyone observes, whether confirmatory of other persons' observations or not, should be made public as far as possible. The paper treats of the drawings of sun-spots and faculæ made in 1889, the period of least frequency, of a series of photographs of spot-spectra in the yellow-green region and in the region about H, K, and concludes with some remarks upon the connection between sun-spots and terrestrial magnetic disturbances.

The Author then explained the reason of his selection of the year of minimum solar activity for a preliminary examination of the drawings. He said that he had hoped that a careful study of the movements of the spots at this time, when they could be followed with less fear of confusion between old and new formations, might lead to some well-defined rule for the selection and treatment of the landmarks for the surface rotation; but that he had found that their erratic behaviour, even after the first days of their lives, was such that no improvement on Carrington's measures seemed possible without a very long series of observations, and that probably Carrington's remark upon his own work was no exaggeration—that no better result would be obtained under an expenditure of £5000.

The positive results from this preliminary examination are as follows:—

1. The spot-charts show a clear confirmation of the difference of rotation velocity in high and low latitudes.

2. The faculæ show the same difference more clearly, and indicate also Carrington's law of this variation.

3. It is highly probable that spot formation is preceded by small bright faculæ.

4. Two high latitude zones of small short-lived faculæ appear on the charts—one south, the other north, the former being the stronger belt.

5. Recurrences of spot formation are shown in eight regions, and nearly always the recurrences are to the rear of the former positions.

Before referring to the photographs of spot-spectra, Father Sidgreaves drew attention to the narrowness of the spot-bands, which was owing to the want of light power sufficient for an amplification of the solar image, and said that the negative results here might be accounted for by this defect of size, but that he thought that negative results should not be kept back.

1. The plates offer no reliable confirmation of the widening of solar absorption lines. The appearance of widening, which is quite noteworthy on the plates, almost entirely fails under micrometer measurements, and there is hardly any perceptible difference between the apparent widening as shown on the plates exposed to the yellow and to the violet rays.

2. The stronger or blacker spots almost completely stop the photospheric radiation.

3. The reversals of H and K over or close to a spot are generally either not double or only feebly so, while they are comparatively widely double away from the spot; showing that the faculous

matter over or near to a spot is at a higher elevation, and falls as it recedes from it. Some plates show no reversal immediately over the spot, strong single reversal just off the spot, and wide double reversal away from it.

Father Sidgreaves then remarked upon the reversals of H and K by the integrated solar light—that the number of exposures made in this manner (*i. e.* with the sunshine thrown upon the slit without a condenser) was not sufficient to draw conclusions from them, and these plates have not been mentioned in the paper. But it might be added that so far it is not clear whether or not the pair of fine bright lines at the centre of the K band are ever absent; that their appearance on the plate depends much upon the time of exposure and fullness of development, and possibly upon the granulation of the plate. More than one plate has shown them at a time when faculæ were very scanty visually, and spots very few.

The Rev. A. L. Cortie. With regard to the widening of the lines, I have not observed the Sun-spots by photography, but I have made a great number of eye observations, though not in the part of the spectrum in which Father Sidgreaves is working, but in the red end, and undoubtedly, so far as eye observations show, the lines are widened in spots; and this is not due to any optical delusion, otherwise we should always have the same relative amount of widening in the lines, and the same lines affected. We have different lines widened, and widened differently at different parts of the spot-period, and in the various spots of the period. Observations of this kind have been made by many others—by Father Secchi, Dr. Vogel, Prof. Young, Mr. Maunder, by Prof. Lockyer and his assistants.

Mr. A. Taylor. There is one other point. Frequently I have noticed that lines which cannot be detected in the solar spectrum are distinctly seen across the spot-band, which is a most conclusive proof that the widening has a real existence and is not optical.

Mr. R. A. Gregory. I have photographs taken at South Kensington which show the lines widened over the spot. I exhibit these at popular lectures, and the appearance is sufficiently marked to be accepted by audiences as evidence that the lines are really widened, and that it is not simply a delusion.

Mr. Maunder. The paper which Father Sidgreaves has presented to the Society raises an exceedingly large number of important questions, and there are two or three questions I would wish to ask him upon it. First with regard to that portion of the paper which dealt with the precedence of the formation of faculæ. Father Sidgreaves mentioned that he had seen cases in 1889 where the faculæ were formed before the spot. I should like to ask whether those spot-groups were near the east or near the west limb, or equally divided between the two, because the strength of the evidence is very different whether we have a spot forming near the west limb or near the east limb. If the facula is seen first near the west limb, I should say it is very strong proof of the prior formation of the faculæ. Then comes the question of the determination of the rotation period; that is a matter of great difficulty. In any long-continued group we find that the group as a whole moves very freely on the Sun's surface, and the individual members of the group move with a still greater freedom. It is, as Father Sidgreaves says, a common thing for the leader spot to rush forward from the group at considerable speed. But, further, when the group has passed its period of greatest activity, and when practically only the leader spot remains, it is not infrequent for the leader spot to travel backwards towards the original seat of formation. Consequently we may take a group and derive three entirely different rotation periods from that one group. If we divide the lifetime of the group into three periods—the period of formation, the period of greatest development, and the period of decline—that will give us widely different results in a great number of cases. With regard to the widening of the spot-lines, the solar spectrum is irregular in this way. The red end shows us by far the greatest number of widened lines and the most conspicuous. Between C and D is a region very rich in lines which widen when the light emanates from a spot. From "D" to "*b*" the widened lines are not so conspicuous or numerous as in the lower region. From "*b*" to "F" I think we get a richer region; beyond "F" to the violet I believe very few have been observed by the eye. But a more certain observation is that of the appearance of new lines over spots, and I should like to ask Father Sidgreaves whether his photographs show any evidence of that. Near the group of "*b*" lines I have over and over again noticed fresh lines which do not appear in the spectrum of the normal solar disk. There is one objection which might be raised against the eye observations of widened lines; and that is, with the small dispersion that I have used it is quite possible that what was observed was not a widening of lines but the appearance of new lines. I should like to have the opportunity of making the observations with a greater dispersion than I have yet done. Theoretically I should say it was not at all unlikely that we should find that the principal absorption in the spot was not a selective absorption but a general, and therefore would not show itself by increased widening of the lines. There are two kinds of absorption exhibited in the solar spectrum—the one selective and the other general. The general absorption shows itself in the diminution of light towards the limb, and the selective in the Fraunhofer lines; and I think the darkness of the spot is due rather to the absorption from solid matter than to that of vapours.

Rev. W. Sidgreaves. With regard to the question of faculæ, I am sorry to say I am not sufficiently clear in my memory as to whether they were on the eastern or western limb. I think the first one we came across was near the eastern limb; the evidence in this case seemed to be quite conclusive. The faculæ were in a position in which no faculæ had been sketched for a very long period before, and there is no trace of the spot until two days after the small faculæ were seen. I am not able to answer the question with regard to the western limb. As to the reversal of lines in the spectra of spots and faculæ, the effect of spots themselves on the reversal of the "H" and "K" lines is absolutely nothing so far I have been able to detect. Whenever any reversal of these lines is detected there is always faculæ near the spot. There may be reversal of the line completely crossing the spot, but my belief is that this reversal is caused by faculæ covering the spot, and when this has drifted away, leaving the spot in all its blackness, no reversal of the lines can be seen.

The President. We have had a very good discussion on this subject. Father Sidgreaves has on several occasions appealed to me on one or two points which I have not been able to pay particular attention to up to the present moment. Many matters have been brought before us by Father Sidgreaves, and one cannot confine one's attention to any particular point; one has to think of the general interest of the paper. For my part I do not think there is much difference between the eye and photography for these observations. Both are affected by irradiation, and that effect will never be got rid of, but probably it will be better eliminated on a photographic plate. With reference to the appearance of lines in the spectrum of a sun-spot, it is practically on all fours with what one would expect. When there is a bright background the fine line would not be able to be seen, and if there is a small dispersion the less those fine lines will be seen. As to the widening of the lines, the whole gist of the thing seems to me to be that two or three lines must be taken in the same region of the spectrum, and it must be observed whether they are all equally widened. They must be lines of the same character, and the same density, and the same fineness, in order to give a practical determination as to whether those lines are formed by physical phenomena which take place in the Sun, or whether they are due to the defects in the photographic plate. Mr. Maunder remarked about the selective absorption; I prefer myself to call this "special" absorption. I think the general absorption has a great deal to do with these spots. We are very much obliged to the readers of these papers.

Prof. Turner read an abstract of a paper by *Mr. R. A. Sampson* on "The Rotation and Mechanical State of the Sun" (*v.* p. 403).

Dr. Isaac Roberts then showed and explained photographs of the Nebulæ ♅ I. 143 and II. 536 Virginis taken with the 20-inch reflector on April 9th, 1894, with three hours' exposure. These nebulæ are described in the New Catalogue and in the General Catalogue; and Lord Rosse recorded the results of seven observations made between 1855 and 1862. The photograph showed the nebulæ to somewhat resemble the letter "D" with the curved side north preceding, and a star of about 15 magnitude in the centre of the curvature, the interior being filled with nebulosity of different densities, within which were four or five star-like condensations. There was no spiral appearance, as suggested by Lord Rosse.

Dr. Roberts next exhibited photographs of the Nebulæ ♅ I. 84, *h* 1442, and ♅ II. 344 Comæ Berenicis, taken with the 20-inch reflector. Lord Rosse recorded six observations of the nebulæ between 1850 and 1867, and described their appearance as a spiral with arms. The photograph showed the formation to be an ellipse and not a spiral. Both the star and the nebulosity surrounding it had well-defined margins, and there was some evidence of nebulous condensation. Within the rings were several well-defined stars which might or might not be connected with the nebulæ. Nebula *h* 1442 had a stellar nucleus surrounded by nebulosity.

Mr. T. Lewis read a note on the binary star κ Pegasi (β 989). In Aug. 1880 Mr. Burnham found the large star to be a close double, and his measurements were given in the 'Monthly Notices' of March 1890. The extreme difficulty of measuring so close a pair seemed to have deterred other observers from attempting observations of this star, but Mr. Lewis had measured this pair recently with the Greenwich 28-inch refractor.

Mr. Lewis in presenting a paper on the orbit of η Cassiopeiæ (Σ 60) said that a better knowledge of the orbit of this star is desirable, and double-star observers ought to give it some attention. The components are of yellow and purple colour, and of the 4th and 7·6 magnitude respectively. This system has an unusually large proper motion of $+0^{s}\cdot136$ in R.A. and $+0''\cdot481$ in N.P.D. The mean of the determinations of the parallax gives $0''\cdot2$.

Mr. Maunder. Mr. Lewis' observation of κ Pegasi is a testimony to his skill and keenness of sight as a double-star observer; and also it may be regarded as satisfactory as showing the defining-power of the new refractor at Greenwich. Of its light-gathering qualities perhaps an observation of my own on Monday night last may furnish some evidence. I looked for the satellites of Mars with it and found them both. There was not the smallest difficulty in seeing and measuring the satellites.

The President. It is a curious thing that all these small companions seem to be blue or purple. There is a theory which tends to show that these stars are not actually blue, but that owing to their faintness they appear to be of that colour. That is to say, it does not follow from the observation that the light which emanates from these bodies is all of the wave-length which causes blue light; but, as in looking at a faint object the first rays which affect the eye are the blue rays, we must not be surprised to hear that these small companions are blue, and we must not build on this foundation any theory as to their constitution.

A vote of thanks was accorded to Mr. Lewis.

Prof. Turner read extracts from a paper by *Dr. A. A. Rambaut* "On the Effect of Atmospheric Dispersion upon the Position of a Star." An important part of this paper dealt with the heliometric observations of *α* Centauri made by Dr. Gill. Dr. Gill himself found a systematic error which he ascribed to the fact that the line joining his eyes was not always parallel to the line joining the pair of objects under measurement. To eliminate this systematic error, Dr. Gill, in his discussion of results, introduced four unknown quantities; Prof. Rambaut substituted one quantity, representing atmospheric dispersion. The value of this quantity determined was ·007 of a second of arc, and the residuals were not much larger than those found by Dr. Gill. Prof. Rambaut also discussed Dr. Elkin's measures of *α* Centauri. Although he had introduced this new hypothesis into the discussion of the measures for the parallax of this star, the result was essentially the same as that obtained by Dr. Gill, namely ·74 of a second of arc instead of ·75 obtained by Dr. Gill.

Prof. Turner added: I was struck by the remark that Prof. Rambaut attributes a change in the amount of the dispersion to the fact that a gauze screen was used to diminish the light, and I did not see how a diminution in light might cause a change in colour. From the remark of our President, however, that change of magnitude of a star is perhaps in some cases synchronous with a change of colour, it is possible that this point in Prof. Rambaut's paper may be found to be more nearly connected with fact than I supposed.

The President. The paper is one which requires careful consideration. Whether it affects the results of Dr. Gill's observations remains to be proved. However, all such papers as these are of value, and we should pass a vote of thanks to Dr. Rambaut for having given us the opportunity of considering this question.

Mr. Maunder. Might I mention what I thought a very pretty illustration of the point the President raised, that a faint light appears to us of a bluish tint. In the late Lord Beaconsfield's romance of 'Alroy' he represents the Hebrew army as encamped on the eve of the Sabbath. The Rabbis stand watching the effect of the light on skeins of white silk. So long as the skeins appear rosy the work of the camp goes on; when they turn to gold the preparations for the Sabbath are pushed on; when they have become blue all is hushed and at rest throughout the camp, the Sabbath has begun.

Mr. Stone made some remarks on his comparison of the new Radcliffe Catalogue for 1890 with the Greenwich Five-Year Catalogue 1890. A comparison of the North Polar distances of these catalogues showed a systematic difference. For stars near the pole this difference was insensible; for stars of N.P.D. 52° to 103° it amounted to about about $0''\cdot8$. Mr. Stone suggested that this might be caused, to a great extent, by the application of the R—D correction at Greenwich; but, of course, it was not pretended that the Radcliffe observations were free from systematic error. On comparing the Radcliffe observations with those of the Cape 1880 catalogue a closer agreement was found; but there was in this case a systematic difference of 0″·4, the Cape results being nearly a mean between the Radcliffe and Greenwich observations. Mr. Stone considered 0″·4 was not a large residual from the point of view that the making and comparison of these observations was equivalent to measuring an arc of 180°.

Mr. Thackeray read a paper on "A Comparison of the Poulkova Catalogue 1885 with the Greenwich Ten-year Catalogue 1880 and the Greenwich Five-year Catalogue 1890," from which it appeared that there was a very satisfactory agreement existing between the declinations observed with the vertical circle at Poulkova and those with the transit-circle at Greenwich.

Prof. Turner read a paper by *Dr. Gill* on the latitude of the Royal Observatory, Cape of Good Hope. Dr. Gill, on comparison of the recent Greenwich and Cape catalogues, had found a correction to the latitude of the Cape of 0″·2, and a correction to the latitude of Greenwich of 0″·1. Though sensible, these corrections were not so large as those found by Mr. Stone. Dr. Gill further suggested the diminution of the constant of refraction by $\frac{2}{1000}$ of its amount. The occasion of the present paper was the publication of a series of fundamental observations at Poulkova, which had enabled Dr. Gill to get his latitude with very great accuracy, and confirmed his previous results.

Mr. Downing. With regard to the discordance detected between zenith-distances as measured by different instruments, I have lately had the opportunity of seeing Dr. Gill's results, which will appear in his forthcoming Cape Catalogue, 1885. He gets a discordance of 0″·5 between the Cape and Greenwich at ten degrees north of the equator. There is one point worth mentioning, and that is that zenith-distances at Greenwich are reduced to the mean of reflection and direct results. I cannot see any justification for that course, but I think it has always been adopted at Greenwich; and with our present lights on discordances between reflection and direct observations, I should say it is erroneous, and the direct results ought to be taken as correct.

The following papers were announced and partly read:—

Prof. E. W. Brown. "Note on the Lunar Theory."

W. H. Finlay. "On the Computation of Star Corrections."

Isaac Roberts. "Photograph of the Nebulæ ♅ I. 84, *h* 1442, and ♅ II. 344 Comæ Berenicis."

Isaac Roberts. "Photograph of the Nebulæ ♅ I. 143 and II. 536 Virginis."

W. G. Thackeray. "Comparison of the Poulkova Catalogue 1885 with the Greenwich Ten-year 1880 and Five-year 1890 Catalogues."

T. Lewis. "Note on the Binary Star κ Pegasi (β 989)."

T. Lewis. "On the Orbit of η Cassiopeiæ (Σ 60)."

David Gill. "Note on the Latitude of the Royal Observatory, Cape of Good Hope."

Rev. W. Sidgreaves. "Notes on Solar Observations at Stonyhurst College Observatory."

Prof. A. A. Rambaut. "On the Effect of Atmospheric Dispersion upon the Position of a Star."

W. E. Plummvr. "Preliminary Note on the Position of the Liverpool Observatory."

W. E. Plummer. "Observations of Comet II. 1894 (Gale), made at the Liverpool Observatory."

R. A. Sampson. "On the Rotation and Mechanical State of the Sun."

Prof. S. Newcomb. "Note on Mr. Stone's Theory of the Measure of Time."

E. J. Stone. "A Comparison between the results of the Radcliffe Catalogue of Stars 1890 and the Greenwich Five-year Catalogue 1890."

The following gentlemen were elected Fellows of the Society:—

Major Archibald Drummond, Guards' Club, Pall Mall, S.W.; *S. Maitland Baird Gemmill*, 254 St. George's Road, Glasgow; *Samuel A. Saunder*, M.A., Wellington College, Berks.

The following gentlemen were elected Associates of the Society:—

Prof. A. A. Michelson, University, Chicago; *Prof. H. Poincaré*, à l'Institut, Paris.

The following Candidates were proposed for election as Fellows of the Society:—

J. J. Aubertin, 33 Duke St., St. James's, S.W. (proposed by Sir R. S. Ball).

C. J. Greene, M.R.C.S., 10 St. Paul's Square, Preston (proposed by R. Wilding).

Frederic Hammond, F.R.I.B.A., 2 Mercer's Road, Tufnell Park, N. (proposed by J. I. Berry).

William Harnett, Cullentra, Wimbledon Park, S.W. (proposed by John Browning).

Rev. Thomas Roseby, M.A., LL.D., The Parsonage, Marrickville, Sydney, N.S. Wales (proposed by R. T. A. Innes).

Rev. Peter Hately Waddell, M.A., B.D., The Manse, Whitekirk, East Lothian, Scotland (proposed by William Peck).

Robert Wigglesworth, York (proposed by A. A. Common).

BRITISH ASTRONOMICAL ASSOCIATION.

THE Annual Meeting of the British Astronomical Association was held in the Botanical Theatre, University College, on Wednesday evening, 31st October, Dr. A. M. W. Downing, M.A., F.R.A.S., President, in the Chair.

Mr. P. F. Duke, the senior Secretary, read the names of 31 candidates for membership, including 10 from Sydney, New South Wales, and mentioned that 23 candidates for membership were reported by the new West of Scotland Branch. The election of 5 new members by the Council was confirmed by the Meeting, after which the year's accounts were passed as presented.

Miss Everett read extracts from the Report of the Council on the Progress of Astronomy during the year ending September 30, 1894.

The retiring President then delivered his address, in which he expressed his satisfaction at the continued success and prosperity of the Association, which now numbered nearly a thousand members. The financial state of the Association was satisfactory, property had accumulated, the Journal and the Memoirs had improved, and he was gratified to say that the North-western Branch was firmly established, and that other branches in Glasgow and New South Wales were in process of formation. The President also referred to the position of ladies in the Association; the list of officers for the coming session showed that three ladies had been elected to important posts, and he alluded also to the continued generosity of Miss Brown.

The Report of the Scrutineers of the Ballot having been read by Mr. Kennedy,

Votes of thanks were passed to the retiring Members of the Council, the Auditors, the Scrutineers, and the retiring President.

Mr. E. Holmes read a paper on "Star Streams," in which considerable reference was made to an article by Mr. Wesley in the August number of 'Knowledge.' Any number of stars he maintained, in almost any order, could be connected by irregular curves, but that a number of stars in streams or lines, curved or otherwise, should be connected by nebulosity had always appeared to him something astounding. The instance most often quoted, and therefore, he supposed, most strongly relied on, was the so-called "celestial way" in the Pleiades. At first sight a nebulous band did appear to connect seven stars, but there was a great lack of scientific exactness in all descriptions of it. He referred to the exaggerated disks of all stars upon photographs, and considered that the appearance of a line was often caused by the overlapping of the exaggerated disks of stars where they happened to be more numerous than in neighbouring parts of the photograph.

Mr. Wesley said that Mr. Holmes appeared to have misunderstood the point of his paper. It was intended to call attention to the very remarkable dark patches amongst a great crowd of stars.

If the stars were all on one plane, it would be very natural that there should be such rifts, but what the form of any kind of rifts could be, seeing that the stars were spread through space, seemed to him an insoluble problem. He felt inclined to adopt Mr. Ranyard's hypothesis, and to regard the rifts as due to some light-absorbing matter.

Mr. E. W. Maunder objected to Mr. Holmes' statement that photographs of clusters always showed nebulosity, and referred to one taken by Dr. Russell, of the Sydney Observatory, which showed no trace of nebulosity after 12 hours' exposure. He also reminded the audience that Mr. Proctor had discussed the point raised by Mr. Holmes several years ago, and had pointed out that wherever—roughly speaking—they found a cluster of bright stars they also found a tendency to cluster in fainter magnitudes. He thought there was no getting over Mr. Proctor's argument, and that they must regard apparent clusters as, in the main, real clusters, notwithstanding the vast range of magnitude they showed.

Dr. Roberts said that Mr. Holmes had raised an important question, but that he had gone further than he would have done if he had been fully on his guard. There were numerous photographs of spiral and elliptical nebulæ in the library of the Royal Astronomical Society that had undoubted stars and star-like condensations in the streams of nebulosity. He had always regarded the nebulous line in the Pleiades as an elliptic or circular nebula seen edgeways. The bright stars that were seen in that long line might not belong to it. They could not assume that the line was caused by the overlapping of the photographic disks of the stars, for if that was the case there would be some irregularity, but on no photograph was there any trace of the breaking-up of the nebulosity.

Mr. E. W. Maunder read some notes on recent observations of Linné by Herr Leo Brenner, in which the observer stated that on June 10 he saw, with a distinctness that excluded every doubt, that Linné was still a crater with walls, but that it had probably changed since Mädler's time.

Mr. Green remarked that many years ago when the question was agitated he had seen Linné as a crater very clearly indeed, and possessed a drawing of it that he had made at the time.

The Meeting then adjourned.

ROYAL METEOROLOGICAL SOCIETY.

The opening meeting of the session was held on Wednesday evening the 21st instant, at the Institution of Civil Engineers, Westminster, Mr. R. Inwards, F.R.A.S., President, in the Chair.

Dr. H. B. Guppy read a paper on "Suggestions as to the Methods of determining the Influence of Springs on the Temperature of a

River, as illustrated by the Thames and its tributaries." The methods suggested were:—1. Comparison of the curves of the monthly means of the temperatures of the air and of the water for the river under observation with those of a river beyond the controlling influence of springs. 2. Comparison of the monthly means of the temperature of the river under investigation with that of a river beyond the control of the springs. 3. Comparison of the range of the monthly means of the river temperature with that of the air in the shade. 4. Comparison of the daily range of water temperature at different stations along a river's course. 5. Comparison of sunrise observations made at different stations along a river's course. 6. Comparison of observations made at different stations along a river's course at the hour of maximum temperature. 7. Comparison of the results obtained from a single series of observations made in one day along the whole course of a small tributary like the Wandle, or along the upper course of a larger tributary as the Kennet. 8. Determination of the distance from its sources at which the river begins to freeze.

Mr. Eric S. Bruce, F.R.Met.Soc., exhibited and described some lantern-slides showing the disastrous effects of the great gale of November 17th and 18th, 1893, upon trees in Perthshire, Scotland.

Mr. Alfred B. Wollaston gave an account of the formation of some waterspouts which he had observed in the Bay of Bengal.

Notes on Mars in 1894.

The great Cloud-Formation of October.—Mention was made in the November number of 'The Observatory,' p. 349, of the remarkable obscuration of the continental region lying north of the Mare Cimmerium, and of the Mare Cimmerium itself, by what was probably cloud or mist. Various interesting particulars concerning this have since been published by other observers, and it would appear beyond doubt that it is by far the greatest and best authenticated instance of the kind hitherto recorded. The change produced in the appearance of the planet was so enormous and so striking that I hardly dared believe the evidence of my own eyes. The Maraldi Sea of Mr. Green's map is one of the largest, darkest, most definite, and most characteristic of the Martian seas. Yet the greater part of this extensive sea disappeared altogether from view! And in addition the great continental region extending from this sea up to about north latitude 20° was also densely obscured by cloud or mist, together with the peninsula Hesperia. In view of the extent and importance of this vast cloud-formation, which must considerably modify our ideas concerning the Martian meteorology, I give below an analysis of such observations as have come to my knowledge up to the present time. The record is already fairly complete as regards the general aspect, though when further observations and drawings come to be published we shall doubtless have much additional and important information concerning the details of the phenomenon. In the following account "the continent" means the large continental area extending from the Maraldi Sea up to about N. latitude 20°. East and west are used in the same sense as they are on the Earth. The Mare Cimmerium constitutes the western and larger portion of the Maraldi Sea; the Mare Sirenum the eastern and smaller portion of the same. The observer's names are given in brackets at the end of the observations.

Oct. 10, 9^{h}–10^{h}. A veil of cloud or fog extended over all the region to the east of the Syrtis Minor, hiding the eastern part of the Mare Tyrrhenum and the whole of the Mare Cimmerium. (Flammarion.)

In a drawing of the same date the M. Cimmerium is shown quite pale compared with the M. Tyrrhenum, and Hesperia abnormal. No canals appear on the continent. (Schiaparelli.)*

Oct. 12, 9^{h}. "The Mare Cimmerium, which was *very* dark in August and less dark in September, is now the brightest of all seas." In a drawing it is shown quite pale compared with the M. Tyrrhenum. Canals on the continent well seen. (Brenner.)

Oct. 14, $8\frac{1}{2}^{h}$. The middle portion of the M. Cimmerium is drawn bright, like an abnormal development of the island Cimmeria. The canals on the continent seem to have been remarkably distinct and well seen, the Orcus being double and the Cerberus broad. (Brenner.)

$8\frac{1}{2}^{h}$–$10\frac{1}{2}^{h}$. The Maraldi Sea faint white, just a trace of the north edge could be seen. Zephyria, Aeolis, and Aethiopis were bright orange, the south border of these helping to define the N. border of the Maraldi Sea. Hesperia whitish. (MacEwen.)

$10^{h}\ 10^{m}$–$10^{h}\ 45^{m}$. Hesperia very bright and rather white. The western part of the M. Cimmerium seemed unusually narrow and inconspicuous, not much broader than the Triton. It was suspected to be much overspread by cloud. (Williams.)

Oct. 15, $9\frac{3}{4}^{h}$–$10\frac{3}{4}^{h}$. The details appeared the same as on the 14th. (MacEwen.)

$9^{h}\ 45^{m}$–$10^{h}\ 15^{m}$. "The Mare Cimmerium has practically disappeared." Only a narrow, faint, indefinite streak was visible along the coast of Hesperia. At the west end of this streak was a darker spot. The continent bright yellowish-white and destitute of canals, as described in 'The Observatory' for November, p. 349. (Williams.)

Mr. Cammell has a drawing made on this night, but about an hour later than my observation, which shows nothing abnormal beyond the M. Cimmerium being rather pale. At this time, however, the region was too near the limb to be well observed.

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* For further particulars concerning the observations and drawings of Messrs. Brenner and Schiaparelli see 'English Mechanic,' November 2 and 16. Professor Schiaparelli remarks that he had never before seen such enormous variations in this region.

Oct. 16, $9\frac{1}{2}^{h}$. "The Mare Cimmerium is visible only along the coast of Hesperia; the rest was brighter than the continent, as if covered with clouds." (Brenner.) His drawing closely resembles one of mine made on the preceding night. No canals are shown on the continent, though the definition was "the best possible." Compare this with his observation of the 14th, when the canals were so very well seen.

$9^{h}\,50^{m}$–$10^{h}\,15^{m}$. "Hesperia is very brilliant and cloud-covered, and the Mare Cimmerium is hardly to be traced, being nearly all cloud-covered. It is a most extraordinary sight." The Mare Sirenum seemed faint and indefinite. No canals seen on the continent. (Williams.)

Oct. 17, $10^{h}\,0^{m}$–$10^{h}\,20^{m}$. Mare Cimmerium nearly all hidden by cloud, from beneath which a small portion at the west end and a fragment of Hesperia projected. This small portion was about as dark as the M. Tyrrhenum. M. Sirenum seemed faint and indistinct. (Williams.)

Oct. 19, $10^{h}\,30^{m}$. West end of M. Cimmerium was dark and definite as far as the mouth of the Cyclops; the rest of the Mare being as bright as the continent, excepting a narrow, faint, indefinite dark channel on the south. M. Sirenum dark, but shape peculiar. (Williams.)

Oct. 21, $8^{h}\,30^{m}$–$8^{h}\,50^{m}$. M. Sirenum dark and definite up to about the place of Titanum Sinus, but from here the Maraldi Sea disappeared entirely. The latter part was actually *brighter* than the continent. (Williams.)

10^{h}–$11\frac{1}{4}^{h}$. "Mist over the Maraldi Sea diffused and faint, making the outline of the north edge difficult to define." (MacEwen.)

Oct. 22, $10\frac{1}{2}^{h}$–$11\frac{1}{2}^{h}$. Observations same as for the 21st. (MacEwen.)

Oct. 27, 8^{h}–12^{h}. "Trouvelot Bay but very dimly seen, and so was the Maraldi Sea, there being a number of white patches visible on it. Hesperia was visible as a faint orange marking." (MacEwen.)

Oct. 28, $7^{h}\,35^{m}$–$7^{h}\,50^{m}$. Mare Sirenum quite faint and inconspicuous. (Williams.)

Oct. 30, 8^{h}–$11\frac{1}{2}^{h}$. The Maraldi Sea very faint, dusky orange or pale brown. (MacEwen.)

Nov. 1, 8^{h}–12^{h}. The Maraldi Sea very faint, pale brown, (MacEwen.)

At the time of writing the Maraldi Sea has quite regained its normal appearance, being about as dark as the Mare Tyrrhenum. So, too, in great measure has the continent. It will be gathered from the foregoing notes that there were considerable variations in the extent of the cloud-envelope from day to day, with local and partial thinnings of the clouds. This is only what might naturally be expected. Various circumstances lead me to think that there was a layer of cloud at a considerable altitude above the surface, and not a mere ground mist or fog.

The Canals.—Cloudy and unfavourable weather has much hindered the observation of these interesting features lately. The Hydraotes was seen double on Nov. 5, the Lacus Lunæ being also double, appearing like two thicker and darker portions of the two lines of the canal. On the other side of the lake the Hydraotes was continued by the Nilus. This appeared dark and definite, but it was too near the limb for it to be possible to say whether it was double or not. On the same night the Ganges and Chrysorrhoas were observed double again. The Amenthes, so broad, dark, and conspicuous in October (see 'Observatory,' November, p. 348), has almost disappeared. It is worthy of note that the remarkable increase in prominence of this canal in October occurred at the time when the continent east of it was enveloped in cloud. The Orcus was observed double by Herr Brenner on Oct. 14, and the Nectar was seen very intensely double in Arizona on Oct. 8 by M. Douglass. So that altogether at least 13 canals have already been seen double at this opposition *.

West Brighton, 1894, Nov. 20. A. STANLEY WILLIAMS.

On the Recurrence of Transits of Mercury.

ATTENTION was called by the Rev. S. J. Johnson in the last number of the 'Observatory' to the close approach of Mercury to the Sun in Nov. 1901. The laws of the recurrence of Transits of Mercury are very simple, but as they are not fully discussed in most of the ordinary text-books it may be advisable to give them here, working out the circumstances of the above close approach as an illustration. In the examination of this subject I have made use of the discussion of the subject by Prof. Newcomb (Astronomical Papers issued by the American N. A. Office, vol. i.). It is necessary to discuss November and May transits separately, as the circumstances of recurrence in the two cases are quite different, in consequence of the large eccentricity of Mercury's orbit. We may in each case, without large error, consider the paths of the planet across the Sun's disk as parallel at all transits; and it will be readily appreciated that the recurrence of a transit at any conjunction of Mercury with the Sun near a node of Mercury's orbit depends on the amount by which the line representing the path has shifted northward or southward since the last transit at that node, the amount of this shift obviously depending on the relative distances from the node at which the conjunctions happen. In the case of the November transits the Sun's diameter is 32′ 24″, and from comparison of the synodic period of Mercury (115·88 days) with the length of the year it will be found that the shift in the path of the planet on the Sun's disk is as follows:—

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* According to a recent telegram two additional canals (Phison and Euphrates) were seen double by Mr. Lowell on Nov. 19. Titan and Eumenides are also double.

After 6 years	31	35″	N.
„ 7 „	23	16	S.
Hence after 13 years it is	8	19	N.
„ 46 (3×13+7)	1	41	N.
„ 217 (14×13+5×7) .	0	14	N.

Since the space between the paths at an interval of 6 years is so nearly equal to the diameter of the Sun, the occurrence of two transits separated by 6 years is rare. The last occurrence was in the years 1776, 1782, and the next will be 217 years later, in 1993, 1999. There will probably not be another case after this till two or three times the 217-year period.

We can now deduce from the circumstances of any one November transit those of others for a considerable interval of time before and after. For example, let us take the recent transit, when Mercury passed 4′ 26″ North of the Sun's centre. In

Nov. 1900	it will pass	36′	1″	N.	of the Sun's centre,
1901	„	18	50	S.	„
1907	„	12	45	N.	„
1914	„	10	31	S.	„
1920	„	21	4	N.	„
1927	„	2	12	S.	„
1940	„	6	7	N.	„
1947	„	17	9	S.	„

and so on.

There will thus be transits in Nov. 1907, 1914, 1927, 1940, while in 1901, 1920, 1947 it will pass at distances of 2′ 38″, 4′ 52″, 0′ 57″ respectively from the limb. Of course perturbations (which are neglected here) will disturb these results to a small extent, but certainly not sufficiently to bring the planet on the Sun in 1901.

We can also by the above rules trace the circumstances of transits before 1894. We thus determine that

in Nov. 1848	the planet passed	2′	45″	N.	of the Sun's centre,
1861	„	11	4	N.	„
1868	„	12	12	S.	„
1881	„	3	53	S.	„

which values agree very closely with the actual ones given in the 'Nautical Almanac.'

In the transits from 1848 to 1940 we see that the intervals are as follows: 13, 7, 13, 13, 13, 7, 13, 13 years respectively. For long periods this sequence prevails without discontinuity till the gradual working northward of the 46-year period (13+13+13+7 years) brings on a new transit on the south limb of the Sun, or removes one on the north limb. It is at these times alone that we can get a 6-year interval, but it is possible (as stated above) to pass through one of these critical periods without a 6-year interval. The following Tables exemplify the two cases :—

In Nov. 1986 the planet will pass 7′ 47″ N. of the Sun's centre.
1993 „ 15 29 S. „
1999 „ 16 6 N. „
2006 „ 7 10 S. „

The law of recurrence in this case is 7, 13, 13, 7, 6, 7, 13, 13, 7. On the other hand, 217 years later we find

in Nov. 2203 the planet will pass 8′ 1″ N. of the Sun's centre,
2210 „ 15 15 S. „
2216 „ 16 20 N. „
(very close approach, but probably no transit)
2223 „ 6 56 S. „

the law of recurrence being here 7, 13, 13, 7, 13, 13, 13, 7—*i. e.* with only two 13-year intervals at the critical period instead of three.

The transit of 1664 referred to by the Rev. S. J. Johnson was 217 years before that of 1881, whence the planet passed 4′ 6″ South of the Sun's centre in 1664, as compared with 4′ 26″ North in 1894. Applying the period of 79260^{d} 6^{h} 24^{m} given by Prof. Newcomb, we find that ingress took place at 3^{h} 55^{m} G.M.T., the middle of the transit at 6^{h} 33^{m}, and egress at 9^{h} 11^{m} G.M.T., these values being almost identical with those in the recent transit. The conditions as to visibility in England were thus practically the same.

It may be noted as an interesting circumstance that the next two transits of Mercury will both be entirely visible at Greenwich. That of 1907 begins Nov. 13^{d} 22^{h} 26^{m} G.M.T., the middle is Nov. 14^{d} 0^{h} 7^{m}, and the end Nov. 14^{d} 1^{h} 48^{m}. That of 1914 begins Nov. 6^{d} 22^{h} 3^{m}, the middle is Nov. 7^{d} 0^{h} 5^{m}, and the end Nov. 7^{d} 2^{h} 7^{m}.

We pass now to the consideration of May transits. In this case the Sun's diameter is 31′ 44″.

The shift in the path of the planet across the Sun is :

	After	6 years	....	65′ 37″ S.
	„	7 „	....	48 21 N.
Hence,	„	13 „	it is	17 16 S.
	„	33 „	....	13 49 N.
	„	20 „	....	31 5 N.
	„	46 „	....	3 27 S.
	„	217 „	....	0 17 N.

May transits are therefore not possible after intervals of 6 or 7 years; an interval of 20 years is just possible, but very rare: there will possibly be a case of the kind in the years 2154, 2174, the first being a mere graze on the south limb of the Sun and the second a very short transit on the north limb.

If we start with the transit of May 9, 1891, in which Mercury passed 12′ 34″ South of the Sun's centre, we deduce that

in 1904 it will pass 29′ 50″ S. of the Sun's centre,
1911 " 18 31 N. "
1924 " 1 15 N. "
1937 " 16 1 S. "
1957 " 15 4 N. "
1970 " 2 12 S. "
and so on.

There will thus be transits in 1924, 1957, 1970, a very close approach in 1937, and a fairly close approach in 1911. The law of recurrence is, as a rule, 13, 33, 13, 33, 13, 33 years, but occasionally there are two consecutive intervals of 33 years, as in the case of 1891, 1924, 1957, while very rarely there is an interval of 20 years, as stated above; in this case the intervals run 13, 33, 13, 20, 13, 33, 13, and so on.

It is necessary to remark that the errors in the above rules produced by perturbations are considerably larger in May than in November.

It remains to indicate the connection between May and November transits. A central May transit is followed by a November one 3½ years later, 1′ 40″ S. of the Sun's centre, while for each minute of arc that the May transit is North or South of the Sun's centre we must shift the November one 29″·6 South or North respectively. Thus any May transit of Mercury must necessarily be followed by a November one 3½ years later, not more than 9′ from the Sun's centre. On the other hand, a November transit is only followed by a May one 3½ years later, if the first one be at least 14′ N. of the Sun's centre; a November one is followed by a May one 9½ years later if the first be at least 2′ 20″ S. of the Sun's centre. The shortest possible interval between two transits is thus 3½ years, while the longest is 13 years, the average interval deduced from a long period being about 7⅝ years.

A. C. D. Crommelin.

Selenographical Notes.

Messier and Messier A.—Though the pair of conspicuous craters in the Mare Fœcunditatis commonly known, by reason of the two light streaks which radiate from them towards the east, as "the Comet," must from their peculiar appearance have long been familiar to observers, they were brought prominently into notice by Webb, who asserted, in the first edition of his 'Celestial Objects,' that the similarity in size, form, depth, brightness, and even in the position of the peaks upon their rings, noted by Mädler, who, between the years 1829 and 1837, examined them more than 300 times, no longer existed, and he hence believed that we have in these objects decided evidence of modern eruptive action. Examining them on various occasions during the years 1855–1859 with a 5½-feet achromatic, and also with his 5½-in. telescope by Alvan Clark, he saw that Messier A, the more easterly of the two craters, was very evidently the larger. On March 11, 1856, he found Messier, the western crater, not only the lesser, but obviously longer in an east and west direction; and finally, in 1859, with his Alvan Clark, considered Messier much shallower than its companion. These observations were subsequently confirmed by other observers; and if reliance can be placed on Mädler's unusually extended notes, we have here a clear case of change. Schröter, observing the pair nearly a century ago, draws, in an apparently careful sketch, Messier *larger* than its companion! which, as Neison remarks, indicates a gradual change in dimensions. Unfortunately, however, his reputation as an accurate draughtsman does not stand high, though, in my opinion, many of his Lunar drawings, despite their roughness, are more true to nature than some of far greater pretentions.

Schmidt's representation of Messier and Messier A in his chart is closely in accordance with Webb's description. The inequality in size is distinctly displayed, as is also the irregularity of form, Messier A being shown as clearly longer in a meridional than in an east to west direction, as exhibiting two short blunt internal spurs or projections from the north-east and south-west walls respectively, and as being connected with Messier by a narrow ridge or wall. Observing these formations with a 4-in. Cooke achromatic, under a rising Sun, at 5^h 35^m on Jan. 14, 1872, a power of 200 clearly revealed to me the unequal dimensions and difference in shape of the pair, Messier being slightly oval, the longer axis directed from west to east; while A resembled the capital letter D, the straight portion facing the S.W. At the time of observation both craters appeared to be about half filled with shadow. Under date 1883, March 12, 7^h, the Rev. F. B. Allison, F.R.A.S., sent me a very elaborate and excellent sketch made under morning illumination, when the terminator lay a little west of Lubbock. In the accompanying notes he describes Messier as "distinctly more rectangular than round." Messier A is shown much as I saw it in 1872. As in Schmidt's chart, it is connected with Messier by a narrow neck or wall, and "on each side of the neck and of the east walls of Messier were shadows much less deep than those within the craters." On the south side of Messier A he draws the outer slope of the wall as extending for some distance beyond the limits of the formation, and describes it as descending gradually to the plain, bordered on either side with shadow; while on the north border he notes a distinct notch, which is probably a craterlet. In the years 1880 and 1884 the craters were observed by M. E. Stuyvaert, of the Brussels Observatory, with an equatorial of about 6 in. aperture. Two excellent drawings, resulting from these observations, are given in his

'Dessins de la Lune.' One under date 1880, Feb. 16, 14^h 40^m B.M.T. (the evening terminator lying a few miles west of the pair), shows Messier as notably smaller than its companion. Both appeared to him under the form of ellipses whose major axes were not parallel, that of Messier being more inclined to the south-east. The shadow of the border of A extended up to the interior of Messier. Though he does not allude to it in his notes, M. Stuyvaert draws a brilliant point near the south-eastern rim of Messier, which evidently represents part of the connecting neck or wall shown by Schmidt and Allison.

In the second drawing made 1884, 31 March, 8^h 15^m, the terminator lying near 19° to the east of the formations, the western crater seems to be very nearly round and smaller than the other. An interruption in the shadow of the eastern border of Messier indicates the presence of a depression thereon. Messier A prominently displays a triangular shape, and from its eastern rampart a well-marked spur or projection was noted, extending towards the south. This is not very plainly shown in the drawing, but it is apparently the same object recorded by Mr. Allison on March 12, 1883.

These observations, and many others which might be quoted, point to the probability that Webb's contention is true, and that there is a strong case in favour of the supposition that both these objects have notably changed since Mädler's time. We have every reason to attach great weight to his records, as he was not only a most careful observer, but he devoted perhaps more attention to them than to any of the multifarious formations which came under his notice in the preparation of his great map. It is to be hoped that these remarkable craters will be critically examined with some of the large instruments now so frequently devoted to selenographical work, so that we may obtain the results of a scrutiny of their details with higher powers than have hitherto been used.

Beaumont House, Shakespeare Road, T. Gwyn Elger.
Bedford, 1894, Nov. 19.

The recent Transit of Mercury.

Few observers on this side of the Atlantic seem to have had favourable conditions for observing this phenomenon on Nov. 10th last. A beautifully clear sky in the morning at Greenwich raised some hopes of success, but clouds coming up from the west obscured the Sun from about an hour before the predicted time until sunset. The following are accounts from all the stations at present reported.

At Meudon, where M. Janssen was prepared to observe with the large refractor of 62 cm. aperture, and M. de la Baume Pluvinel from an elevated position on the top of the great dome, with a smaller instrument, clouds obscured the Sun at contact, but through a break in the clouds later M. de la Baume Pluvinel was able to see the planet on the disk. M. Janssen had made arrangements for observing the times of contact, but especially he intended to devote his attention to the appearance of the planet on the disk, to repeat, if possible, his observation of Venus at the Transit of 1874, when he saw this planet "before the first contact as a detached black spot two or three minutes of arc from the solar disk that it was about to meet. This observation shows the presence of a luminous medium around the Sun, and this medium can only be the coronal atmosphere" *.

M. Trouvelot transferred himself for the occasion to the Observatory of the Astronomical Society of France, as the western horizon of his own observatory is shut off by trees. Clouds prevented him also from observing the contacts, but he was able later to see Mercury on the disk; he says:—"Mercury with clearly defined limbs appeared like an intensely black spot on the bright background of the Sun. In spite of my endeavours I was not able to trace the luminous ring that I had observed round the planet in the transit of 1878; but the actual conditions being much less favourable on account of the nearness to the horizon and the presence of reddish vapours, may explain the absence of the ring."

In England, at Mr. Cuthbert Peek's Observatory, Lyme Regis, the phenomenon apperrs to have been observed with perfect success. The times of the contacts were noted and the chronometer error and rate determined. The observer says: "There was no trace of the white spots nor of the light and dark rings surrounding the planet. On the contrary, the planet's progress over the faculæ and mottled surface of the Sun could be clearly seen, and during the twenty-five minutes of observation it was a very black, circular, well-defined spot."

Major Battersby, who was observing at Westmeath, was not able to observe the contacts, but saw the planet on the disk; he says: "As for the planet it appeared to me circular and surrounded by a faint misty ring, but this was probably only caused by the extremely bad definition."

Dr. G. B. Longstaff, observing at Morthoe, North Devon, with a 3-inch refractor, says: "The planet was very clear, and appeared much darker than the sun-spots. No white spot or halo."

Prof. Turner's observation at Sidmouth, South Devon, is referred to on another page. It will be seen that he did not note any halo surrounding the planet.

We understand that the Transit was seen at Belfast, Portsmouth, and Gibraltar, but have no details of these observations.

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* M. Janssen says on this point: "The fact of the visibility of an opaque body at a certain distance from the solar disk shows that the light which is emitted by the solar corona is only partially masked by atmospheric absorption, and thus we may hope to obtain, by the help of appropriate optical means, images of the corona, more or less extended, without the intervention of eclipses."

Mars.

A GREAT portion of the October number of 'Astronomy and Astro-Physics' is devoted to articles on Mars. Anyone who wishes to have the results of the recent work of various observers on the planet should get possession of this number. We regret that limitations of space forbid us giving more than brief extracts.

The number has as frontispiece a copy of Schiaparelli's Map of Mars in 1888, which serves usefully for references. Later in the number, Prof. W. H. Pickering, after giving the chronology of the discoveries of the physical features, translates Prof. Schiaparelli's latest expression of his views, as given in 'Natura ed Arte' for February 15, 1895, of which the following is a short summary.

Mars has at either pole a white region, which may be considered as snow or ice, not dissimilar to the polar regions of the Earth. The centre of the southern area is not immediately at the south pole, but at a point about 180 miles distant from it. Judging from the analogy of the Earth when mountain snow and ice is in a melting state at the end of our comparatively short summer, on Mars, owing to the greater length of the seasons, at the end of the long winter-night the polar regions are in an advanced state of melting; he says: "The long year, nearly double our own, permits the ice to accumulate during the polar night of ten or twelve months so as to descend in the form of a continuous layer as far as parallel 70°, or even further. But in the day which follows of twelve or ten months the Sun has time to melt all or nearly all of the snow of recent formation, reducing it to such a small area that it seems to us no more than a very white point." The water resulting from the melting of the polar snows causes a gigantic inundation into lower latitudes, rushing through a network of distributary canals, to be diffused over the arid surface of the planet. The water condenses into crystals (the temperature on Mars is considered to be not very unlike our own), and forms an atmosphere, not like rain-clouds, for it is always possible to distinguish the physical features of the planet, but rather a thin veil carrying suspended crystals, which, by atmospheric currents, are carried back into the polar regions to form again the white patches.

In another article in this publication Mr. Percival Lowell gives details of the observations at his Observatory, Arizona, from June to September of this year, with some wonderful pictures showing networks of canals with wonderful distinctness. With regard to these canals he writes:—"Most suggestive of all Martian phenomena are the canals. Were they more generally observable the world would have been spared much scepticism and much theory. They may, of course, be not artificial, but observations here indicate that they are, as will, I think, appear from the drawings. For it is one thing to see two or three canals, and quite another to have the planet's surface mapped with them upon a most elaborate system of triangulation."

[To be continued.]

CORRESPONDENCE.

To the Editors of 'The Observatory.'

The approaching Return of Barnard's Comet of 1884.

GENTLEMEN,—

When I wrote last month that Encke's was the only known periodical comet which was due to return to perihelion in 1895, I should have stated that I was limiting myself to those established comets which have been actually observed at more than one appearance.

The comet 1884 II., discovered by Prof. Barnard on the 16th of July in that year, was found to be moving in an elliptic orbit, the period of which was calculated by Herr A. Berberich to be about 1972 days, or 5·40 years. This would have brought it to perihelion again about the 10th of January, 1890; but at that return the comet's position with reference to the Sun would have been very unfavourable for its observation, which was sufficient to account for its not having become visible. In the spring of next year, according to Herr Berberich's calculations, its position should be somewhat more favourable, and the most probable date of the perihelion passage will be 1895 June 3. (See 'Astronomische Nachrichten,' No. 3260, where sweeping ephemerides are given from April 24 to July 3.) During the whole period of this comet's visibility in 1884 it was situated in the southern hemisphere. The perihelion passage took place on August 16, and observations were continued until about the end of October; but the comet was throughout faint and difficult of observation. At the forthcoming return it should be somewhat brighter.

Yours faithfully,

Blackheath, 1894, Nov. 5. W. T. LYNN.

Two new Variable Stars.

GENTLEMEN,—

I am satisfied that Birmingham 96 (Orionis) and 148 (Aurigæ) are variable. Their B.D. mags. are 6·0 and 6·3, respectively; and colour nearly identical and very fine, viz. deep orange-red. Espin has Bm. 96 suspected of variability in his extended Birmingham catalogue. As Espin records their spectra to be of the IV type, they doubtless belong to the 19 Piscium type of variable.

Yours faithfully,

Sunderland, 1894, Nov. 24. T. W. BACKHOUSE.

NOTES.

COMET NOTES.—Encke's Comet was detected almost simultaneously by several observers. Prof. Wolf photographed it at Heidelberg on Oct. 31, it was visually detected with the 28-inch refractor at Nice on the same night, while Dr. Cerulli of Teramo found it independently on Nov. 1. The latter observer says he could not possibly have detected it but for the accurate ephemeris of Dr. Backlund, while the Nice observers state that it was on the extreme limit of visibility with the 28-inch. The following ephemeris is extracted from that by Dr. Backlund, reduced to 5 P.M. at Greenwich:—

	R.A.			N. Decl.			R.A.			N. Decl.	
	h	m	s	°	′		h	m	s	°	′
Dec. 1..	22	26	5	7	15	Dec. 21 ..	22	16	28	4	24
5..		23	5	6	34	25 ..		15	35	3	55
9..		20	44	5	58	29 ..		14	39	3	26
13..		18	55	5	24	Jan. 2 ..		13	26	2	53
17..		17	32	4	53						

The comet is thus well placed as an evening object. Throughout December it is rapidly approaching the Sun and slowly approachiug the Earth, the brightness therefore increasing rapidly. Perihelion passage takes place 1895 Feb. $4^{d}{\cdot}778$ Berlin M.T.

A very faint comet was discovered by Mr. Edward Swift, of California, on Nov. 20, at 17^{h} G.M.T., R.A. $22^{h}\ 18^{m}\ 24^{s}$ S., decl. 13° 7′. The motion was slow easterly. A. C. D. C.

Minor Planet Notes.—The following planets, discovered early in the present year, have been assigned permanent nnmbers:—

Planet.	Date of discovery.	Discoverer.	No.	Planet.	Date of discovery.	Discoverer.	No.
1894 AV...	Feb. 11.	Courty.	384	1894 BA...	Mar. 7.	Charlois.	388
AX...	Mar. 1.	Wolf.	385	BB...	Mar. 8.	Charlois.	389
AY...	Mar. 1.	Wolf.	386	BC...	Mar. 24.	Bigourdan.	390
AZ...	Mar. 5.	Courty.	387				

The vacant number 359 has been assigned to 1893 M, discovered by Charlois, Mar. 10, 1893.

388 is not identical with 1892 S, but must have been close to it in Dec. 1892.

387 will attain the 7th magnitude in favourable oppositions.

Four new planets have been discovered by Prof. Wolf at Heidelberg: BD, BE on Nov. 1, BF, BG on Nov. 7; they are of about the 11th magnitude. BE is remarkable for its rapid motion in declination, 30′ south daily. This probably implies a high inclination of its orbit.

Dr. Schulhof has deduced the following provisional elements:— Epoch 1894 Nov. 4·5 Paris M.T., $M\ 20^{\circ}\ 56'$, $\pi\ 346^{\circ}\ 19'$, ☊ $213^{\circ}\ 21'$, $i\ 26^{\circ}\ 44'$, $\phi\ 26^{\circ}\ 36'$, $\mu\ 746''$, $\log a\ 0{\cdot}4516$. In perihelion, therefore, it will probably approach the Earth within 0·6, and will be well adapted for determining the Solar parallax.

Two more planets, BH, BI, were discovered on Nov. 19, 24, by MM. Borelly and Charlois respectively. A. C. D. C.

An abstract of an erudite paper by Mr. R. A. Sampson, which may lead to a great increase of our knowledge of Solar Physics, was read at the last meeting of the Royal Astronomical Society. The paper was of too technical a character for hasty discussion.

Mr. Sampson has kindly supplemented our brief announcement on p. 384 by the following abstract:—

"This paper consists of two parts: the former deals with the mechanical state of the Sun in view of its gravitation and radiation, and ignoring its rotation. A theory of radiation is formed to investigate the law of temperature, and the conclusion is reached that temperature, pressure, and density throughout the main body do not greatly increase towards the centre, gentle convection currents relieving any tendency to do so, while at the surface these convection currents assume the violent form that is observed. The theory of rotation developed in the latter part cannot be conveniently summarized in a few words. It may be said that nothing is assumed but that the Sun is a body wholly gaseous; then by the theory of the motion of viscous fluids a state of motion is determined for all points of the body, which is consistent with the surface motions as expressed by Dunér's recent observations. It appears that this motion increases slightly inwards. Pending the decision of the Council as to the publication of this paper, the author wishes to state that some of his friends, to whom he has showed it, and who are capable of pronouncing upon its somewhat difficult methods, have not subscribed to its conclusions."

M. Flammarion has been making lately an investigation of the motion of sun-spots of rather a novel kind. He has made a series of observations, not very long, he says, but sufficient to establish the fact that the nuclei of spots rotate on an axis normal to the surface, and in the direction opposed to the motion of clock-hands, looking at the Sun. He gives in 'L'Astronomie' for November instances of three nuclei which rotated through angles of 77°, 152°, and 34° in 3, 4, and 2 days respectively.

In our number for September last we published a short article collecting the recorded observations of Bright Projections on Mars. In this we said that the first observation of a prominence this year was made by M. Perrotin on August 6. We are reminded that in Ast. Nach., No. 3241, there was an announcement of such observations at the Lick Observatory on June 28. Our statement that Prof. Hussey "did not fail to see a prominence on any night he looked," should be qualified by saying on any *good* night—that is, he did not see prominences when the seeing was poor. Also we might have added that Professors Holden and Schaeberle observed these bright points projecting beyond the terminator in June and July of this year. In a letter, for which we have to thank Prof. Campbell, and in which he calls our attention to the above facts, he says: "The idea that the projections are due to elevated regions dates back to July 1890. The first projection was observed in 1890 by Messrs. Holden, Schaeberle, Keeler, and Campbell, and the account of it printed at that time says: 'The simplest interpretation of the phenomenon is therefore that this strip is (or was at the time of observation) elevated above the general surface' [v. Publ. Ast. Soc. Pac. No. 35, p. 105]. The same explanation was adopted by Prof. Schaeberle in 1892, when he wrote: 'Where these dark streaks seem to intersect the limb of Mars, the white areas projecting beyond the terminator of Mars (often seen in June and July during the partial phase) were usually seen, indicating that the dark streaks were elevated above the general surface, and rendered more bright by being projected against a dark background.'

"It may require several oppositions, or possibly several 15-year cycles, to prove that the observed projections are due to mountains."

The Spectrum of Mars.—With reference to his note on his observations of Mars printed in our last number, Dr. Huggins asks us to print the following addendum:—

"Since writing the note on the spectrum of Mars printed in your last number, I find that Professor Campbell does mention incidentally that the early observers sought to eliminate the effect of our atmosphere by observations of the Moon; but the sentence I quoted seems to me to suggest the interpretation I put upon it, and to need the explanation I gave of my early work."

It appears to be a fact that the "largest telescope in the world" is to be a feature of the Paris Exhibition of 1900. At the meeting of the Société Astronomique de France on Oct. 3, M. Mantois gave some details and stated that the order had been given and the work was begun. The instrument is to be 200 feet long and to have an objective of 4 feet diameter, and will be arranged so as to throw images on a screen for the public view. Someone asked, why limit the size of objective to 4 feet? M. Mantois is reported to have said that this was merely a question of the limited time in which it was necessary to make the glass.

In our last number we briefly announced the death of Mr. Edwin Clark, the celebrated engineer. His early enthusiasm for astronomy is shown in the following paragraph, taken from his obituary notice in 'Engineering':—

"It will not surprise any to know that, having taken the view that terrestrial physics formed the best basis of engineering study, he was a devoted astronomer and meteorologist. Indeed, one who knew him well states that not for the most lucrative commission would he desert his astronomical studies when interested in his observations. He was first attracted to what he himself used to term the 'motions of the spangled vault above' when living in the East End of London, after leaving school. His evenings were at his disposal. The little back garden was surrounded by buildings and high chimneys, and although the conditions at first sight did not seem conducive to observation of natural phenomena, the isolation proved an advantage. Completely shut out from all terrestrial subjects, he of necessity looked up, and the fixed points enabled him to observe the course of the Moon and the stars as they appeared and disappeared among the tall chimneys. Without knowing their names, he was not long in becoming familiar with some of the large stars, and in recognizing their appearance as old friends—their daily, even their annual motions. By the assistance of an enthusiastic German shopkeeper close by, and of Ferguson's 'Astronomy,' he was soon able to calculate eclipses, and mounted a cardboard transit instrument and equatorial on a waterbutt at the back of the house. A want of some knowledge of mathematics checked progress, but this was but a small matter to a man whose resourceful, well-directed energy we have already indicated. He applied himself to the study, and, as he himself has put it, his difficulties increased his enjoyment and his progress. His success is testified to by his election as a Fellow of the Royal Astronomical and Meteorological Societies, while some of his pamphlets have been translated into foreign languages."

THE WEATHER IN NOVEMBER.—The past month has been exceptionally warm for the time of year. From the 1st to the 20th (inclusive) the average excess of mean temperature amounted to 5°·8, and the individual excesses on the 1st, 2nd, and 3rd were respectively 11°·4, 10°·6, and 10°·6. This mild weather was accompanied by heavy rains, which, following upon the excessive rainfall of the latter part of October, produced disastrous floods in many districts in the Thames valley. From October 20 to November 20 the rainfall amounted to 6·46 inches, which is in excess of the corresponding average by nearly 4 inches. Notwithstanding the excessive rains, there has been a considerable amount of sunshine—the record at Greenwich, until the 25th, giving the proportion, large for a winter month, of about 30 per cent. of the possible duration.

ON the 13th November a notable magnetic disturbance occurred, commencing suddenly at 2^h P.M. and continuing till 9^h A.M. on November 14. Among the more remarkable movements shown on the photograms may be mentioned a bold increase in vertical force between 3^h and 4^h P.M., and a very considerable decrease in horizontal force and vertical force at 9^h P.M., the decrease in horizontal force at that time amounting to ·014 in parts of the whole horizontal force. The extreme amount of change in declination was about 50′, and very active movements were shown frequently, but were not generally large in amount. There were no remarkable sun-spots recorded on this day.

A CIRCULAR (No. 40) from Wolsingham Observatory, dated Oct. 30, announces that the variability of two Red Stars, R.A. $0^h\ 49^m{\cdot}0$ Decl. $+58°\ 1'$, and R.A. $1^h\ 49^m{\cdot}8$ Decl. $+58°\ 46'$ (1900), has been definitely ascertained.

BUILDING operations are in active progress at Greenwich. Foundations are dug for the north wing of the new observatory and for the new building to house the new altazimuth.

From an Oxford Note-Book.

In the 'Monthly Notices' for last April, Dr. Gill published an important paper on planetary observation, important not only in itself, but as proposing that steps should be taken to call an Astronomical Congress, for considering the best method of determining the positions of the planets. Dr. Gill suggested that the end of the present century would be a fitting opportunity for such a congress and the Royal Astronomical Society a proper body to undertake the arrangements. The matter has been carefully considered by the Society; and although they have not made any official announcement on the subject, it is understood that they do not see their way to carry out Dr. Gill's suggestion, while at the same time fully appreciating the great advance in the science of exact measurement which his work with the heliometer represents.

Dr. Gill's Report for 1893 affords an instance of astronomical courage. The temptation to make observations in such numbers that the reductions cannot keep pace with them is an old and familiar one, but there are not many instances on record of drastic measures being taken to cure the disease when once it has made its appearance. For an observatory furnished with excellent instruments and situated in a good climate to shut its eyes—to put the caps on its telescopes and refuse to look out at the wonders of the heavens until it shall have digested fully the things it has already seen—requires considerable courage on the part of the Director. It is easy to understand how with such a Director as Dr. Gill, observations in the earlier years of his directorate multiplied to excess, if such a phrase may be used to express the fact that the computing staff was not able to keep pace with them. But to find that Dr. Gill has actually ceased observing with his heliometer, the heliometer with which he has done epoch-making work, in order that he may have time to completely reduce and discuss his observations, certainly affords us food for reflection. The work with the transit-circle had already been limited in 1892, and the observations of comets have also suffered for the general good. As a compensation, however, the astrographic telescope has been particularly active, and nearly 1200 plates with short exposures and 100 of exposure of one hour have been taken during the year. Three-quarters of the catalogue plates assigned to the Cape are now taken and prove to be satisfactory. It could be wished that the work were as well advanced at other observatories. Astronomers will look with great interest for the 'Cape General Catalogue' for 1885, which is apparently printed, but of which I have not yet seen a copy.

The completion of fifty volumes by our contemporary 'Nature' was celebrated on November 22 in a most agreeable manner by a dinner at the Savoy Hotel. Messrs. Macmillan, the publishers, entertained about fifty past and present contributors, the guest of the evening being of course Mr. Norman Lockyer, who has edited 'Nature' from the beginning, and who gave an amusing account of some of his experiences during the quarter of a century. He concluded by proposing the toast of the contributors to 'Nature,' for whom Professor Huxley, the very first contributor, replied, being, as may be imagined, very warmly received. He remarked especially on the value of the discipline of putting down in plain language just what is known to be true and leaving out all that cannot with certainty be vouched for, and genially though seriously expressed his opinion that the present generation of writers were in this respect somewhat deficient. In responding for the hosts, Mr. F. Macmillan remarked that if publishers took any notice of what is said about them, they would be no doubt very unhappy. "As a matter of fact," he added, "we are not unhappy"; and the obvious conclusion was greeted with appreciation.

A SUCCESSFUL astronomical expedition, when even the weather is propitious, has in our climate a peculiar charm; and I have every reason to be content with that organized on November 10 by my friend Mr. Lindemann, to observe that small part of the transit of Mercury which could be seen in the West of England. Sidmouth lies almost exactly on a line drawn from London in the direction of increasing favourable conditions, as a glance at the map of the transit published in the French 'Ephemeris' will show. The meeting of the R. A. S. on Friday made it impossible to start for Sidmouth early enough to make any great preparations, and the programme was therefore a modest one. Mr. Lindemann was already provided with a portable telescope, and Mr. Wray the optician very kindly lent me a beautiful three-inch for the occasion. With these it was proposed merely to watch the phenomena of ingress, taking the time if convenient. Mr. Lindemann's observatory had no view of the western horizon; and accordingly the site chosen for the observations was a hill some distance away. On arriving at Sidmouth soon after two o'clock, we found a carriage waiting to convey us and our instruments up the hill; and it would be ungrateful not to mention an excellent lunch which had been thoughtfully put into that same carriage, and which we discussed on the way to the chosen site. A rain-storm of very threatening aspect was then visible in the west, and it was determined not to set up the instruments until this had passed. The rain, indeed, soon came down pretty severely, and we were glad of the shelter of the carriage, from which comfortable refuge we saw a line of bright light gradually extending from the western horizon, and giving hopes of seeing something after all. The rain stopped at about 3.30, and the instruments were quickly set up and all was in readiness fully five minutes before ingress. As sometimes happens, the interval thus most fortunately secured between one storm and the next was beautifully clear, and what, considering the low altitude of the

Sun, may be considered very satisfactory observations of internal contact were obtained. Ten minutes after the internal contact the sky was again quite cloudy and threatening for rain. On driving back to Mr. Lindemann's observatory, however, observations of two clock stars were secured with his little transit instrument. Thus the series of observations was completed with almost the minimum margin for accidents. No particular phenomena, such as a white spot or halo, were observed, although the well-known difficulties of the black drop, increased by the boiling of the Sun's limb, were, of course, only too obvious.

PERHAPS the pleasantest feature about this particular expedition was the absence of serious responsibility. A transit of Mercury is not a vitally important matter in the first instance, and such observations of value as can be made were doubtless secured by American astronomers. Here in England one could enjoy to the full the luxury of going *to look at* a somewhat rare astronomical phenomenon. There is a story about an eminent astronomer who had been on several eclipse expeditions, and yet was heard to remark that he had never seen an eclipse. "But your observations of several eclipses are on record!" it was objected. "Certainly: I have on several occasions made observations, but I have always been too busy to look at the eclipse!" The responsibility of the observations is indeed distinctly oppressive. It is said that Airy once bid farewell to a friend who was starting on an eclipse expedition with the remark "Well! the best I can wish you is cloudy weather. I have been on several such expeditions, and on the whole the most satisfactory were those when clouds prevented observations!"

THE mention of Airy reminds me that there is another story about him, apparently in need of correction. It relates how, on being offered a cigar, he declined, with the emphatic remark "I have a character to lose." The details vary, but I believe this is the current version of the story; and it is generally agreed that the rebuke was administered to one of the Struves. When in Russia in 1887 I found that the story was well known at Pulkowa, but I was not prepared to hear from Otto Struve that Airy was by no means persistent in his objection to tobacco, and had often smoked in his company. The other day, however, I was fortunate enough to hear the true version of the occurrence from "one who had it from" the two persons present on the historic occasion, viz. Wilhelm Struve and Hansen; and though the story is not quite so good in the original, as was to be expected, it explains away Airy's apparent inconsistency. It appears that, so far from refusing a cigar in the above terms, Airy had so far unbent as to join his friends in smoking in his own garden; but on reaching the stump of the cigar, he carefully buried it in the ground, remarking, with a smile, "You must excuse me, gentlemen, I have a character to lose." The historical critic would have little difficulty in deciding which was the true version and which the ornamental, even without the excellent authority that I am scarcely at liberty to specify.

It is a rather sad necessity that most of the picturesque stories are probably untrue. They live long and die hard because of their picturesqueness, and in spite of their untruth. There is at least one other quite apocryphal story about Airy—of his examining a young lady's eyes to see if they were doubly refracting. Another, which I have never been able to verify, relates that a very bad passage and an accident to the boat once landed him in Dublin without baggage or money, and he was fain to call on an eminent mathematician whose name he knew, but whom he had never met, to beg temporary assistance. He was received courteously, but could not help seeing that there were difficulties about accepting his identity; and, promptly rising to the occasion, suggested that, if the eminent mathematician would set him a few problems, he thought he should be able to convince him that at least he was no ordinary impostor!

Of the astronomical stories taught in school-books few have not been threatened and many have been quite demolished. It is now considered scarcely worth remarking that Galileo never said "E pur si muove!" and one does not even feel sure that Newton ever paid particular attention to a falling apple. There is, however, one story about Newton which, though undergoing the inevitable revision, does not lose in interest. It is ordinarily related that he first conceived the idea of a universal gravity in 1665, but laid it aside when he found that gravity at the Moon would be represented by 13·9 while at the Earth's surface it was 16·1; and did not again take up the matter till 1684, when he found that the value of the Earth's radius which he had used in computing the result 13·9 for the Moon had been considerably corrected by Picard's accurate measurements. The hitch in this story is that even in 1665 much more accurate measures of the Earth's radius than the one which Newton used were available, if he had taken the least trouble to get them; and even when Picard's measures were announced at the Royal Society in 1672, Newton did not for twelve years show any interest in their bearing on his theory. Carelessness does not seem an adequate reason for his apparent lack of interest in so fundamental a question. But recently the late Prof. Adams suggested a *vera causa* for the delay. He pointed out that in 1665 Newton did not know how to regard the attraction of a sphere for a body near it. At the distance of the Moon the Earth might reasonably be considered a particle concentrated at its centre; but for a "falling body" this would seem to be no longer allowable. It was not till 1684 that he discovered the beautiful theorem that a sphere attracts *all* bodies near and far, as though concentrated in its centre: and it was not until 1684 that he regarded the comparison of gravity at the Moon and at the Earth's surface as anything but a rough approximation for which it was not worth while to employ accurate numbers.

No. 221.] DECEMBER, 1894. [*Price* 1*s*.

THE OBSERVATORY,

A MONTHLY REVIEW OF ASTRONOMY.

EDITED BY

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All Communications should be addressed to the EDITORS of the 'Observatory,' Royal Observatory, Greenwich, S.E.
Annual Subscription (for the "Companion" and twelve Monthly Numbers):—13 *shillings*.

LONDON:
PRINTED AND PUBLISHED BY TAYLOR AND FRANCIS,
RED LION COURT, FLEET STREET, E.C.

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